The Journal of ENGINEERING EDUCATION

January, 1958 *Table of Contents* Vol. 48, No. 4

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The JOURNAL OF ENGINEERING EDUCATION, official publication of the American Society for Engineering Education, is published ten times per volume during the academic session (October 1 to June 1, *Yearbook-Directory* issue February 15) at Urbana, Illinois. Editorial and business offices 114 Civil Engineering Hall, University of Illinois, Urbana (telephone Champaign, Illinois, 76611, ext. 3378). Open to selected advertising of service to the Society; advertising rates and mechanical requirements on application.

DO YOU KNOW . . . .

► . . . . That in mid-November the individual membership of the Society passed the 8,000 mark? Reaching that total has been a "long haul." Further, that is a true count, for the unaccounted difference between the number of dues cards and yearbook listings is only sixteen.

It is hoped that, by next year, the two records will check perfectly. Of the 8,000 members, about 1,100 are men in industry and 200 are from foreign countries. It has been said there are about 20,000 engineering teachers, so it is apparent that less than one out of three belongs to ASEE. We should do better than that!

► . . . . That the second dues notices for 1957–58 were mailed in mid-November? A total of 2,066 were sent out, 1,379 for eight dollars, 410 for six dollars, 147 for sixteen dollars, and 130 for twelve dollars. If you received one of these cards, will you please remit promptly? It is beginning to look as though the number of six-dollar delinquencies is increasing, but that may be because about fifty per cent of new members are under thirty-six years of age and only about thirty-five per cent of the entire membership is under thirty-six.

► . . . . That some mail always is returned and a list of "address unknown" members is prepared from the returned envelopes? Here is the current list of names of members not getting the *Journal*. If you know where any of them now are located, please inform the Secretary's office.

Paul D. Agarwal
Richard Atherton
Ralph C. Challender
James K. Dawson
John M. English
William L. Garrott
Kenneth E. Haughton
Levi L. Henry
John F. X. Hopwood
Ernst W. Kiesling
Wilkye B. Lowe
Roger H. Nelson
John T. Norgord
Hendrick J. Ooorthuys
Michael S. Pendergast, Jr.
Corwin L. Richard
Chester A. Rumble
Robert B. Seid
Walter W. Stewart
Edward B. Stuart
Herbert S. Suer
John F. Twigg
Milton L. Vogel
Paul C. Zmola

► . . . . That there will be nine ASEE–AEC Summer Institutes in 1958? The four basic or beginning ones will be held at North Carolina State, Cornell, Purdue, and University of California at Berkeley, with an AEC laboratory cooperating in most cases. The specialized institutes are Instrumentation and Control at Argonne, Metallurgy at Ames, Chemical Processing (Q-clearance required) at Hanford, and Reactor Technology at the University of Michigan.

The program for Technical Institute teachers will be at Penn State. Your dean of engineering has all the information and application blanks. See him if you are interested.

► . . . . That the publication of the Nuclear Engineering Education News Letter has been resumed? It is on a monthly schedule and some back copies are available. If you want to be on the mailing list, send your name and address to the Office of the Secretary. If you have news that should be considered for publication send it

to Professor V. E. Bergdolt, Department of Mechanical Engineering, Purdue University, Lafayette, Indiana.

► . . . . That the Society now has an identifying lapel button and pin? It is the same as the emblem on the cover, but about half as large. The letters are white on blue enamel, with the horizontal and vertical "points" gold plated. To obtain one specify whether you want a "lapel button" or "pin" and send three dollars to the Secretary's office.

► . . . . That during the past year there have been a number of comments and discussions relative to the termination of college careers by engineering students for reasons other than graduation? A good summary of studies which have been made in this area is the article by A. Pemberton Johnson entitled, "Graduation, Hold-Back, and Withdrawal Rates in Engineering Colleges," which appeared in the November, 1954, issue of the JOURNAL OF ENGINEERING EDUCATION.

► . . . . That work on a "Retired Professors Registry" is now under way? The Registry will provide a clearing house for retired personnel interested in continuing teaching. Names will be treated confidentially, no lists being made available for circulation. Those planning to retire, and some who may already have retired, and who are mentally and physically able to continue teaching will be invited to register at no charge. An individual folder will be prepared for each registrant and classified as to specialties, preference as to location, type of institution interested in, etc.

Administrators wishing to employ such individuals will be asked to indicate the kind and type of professor they wish to employ. The Registry will then send the administrator the material on the people who appear to fit the specifications. The institution and the individual must then get together. There is no charge to the institution or the individual.

The Registry has been set up for a five-year period, is jointly operated by the American Association of University Professors and the Association of American Colleges, and is financed by a grant from the Ford Foundation. The advisory committee is made up of three representatives of AAUP and three from AAC. The Director and his address are Dr. Louis D. Corson, Retired Professors Registry, 1785 Massachusetts Avenue, N.W., Washington 6, D. C. Information may be obtained by interested persons.

W. LEIGHTON COLLINS
Secretary

NEW AFFILIATE MEMBER

Central Technical Institute, Kansas City, Missouri, has been voted an Affiliate Institutional Member of ASEE by action of the Executive Board.

C. L. Foster, its President, has been an active individual member of the Society since 1948, and currently is serving as a member of the James H. McGraw Award Committee.

THE SANITARY ENGINEER IN THE WORLD HEALTH ORGANIZATION

With Emphasis on Egypt and the Middle East

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School of Civil Engineering,
Purdue University, Lafayette, Indiana

Presented at a Conference of the Sanitary Engineering Committee No. 3 and the Applied Hydraulics Committee No. 5, 65th Annual Meeting of ASEE, Cornell University, Ithaca, New York, June 20, 1957.

Recommended by the Sanitary Engineering Committee

"The health of all peoples," states the constitution of the World Health Organization, "is fundamental to the attainment of peace and security and is dependent upon the fullest cooperation of individuals and States." This idealistic document further defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."

To the sanitary engineers, the doctors and nurses, and all the other public health workers on the W.H.O. roster is entrusted the responsibility of spelling out in terms of the practical, everyday life of the people of the 88 member nations this ideal of health and healthful environment for all peoples.

The sanitary engineer in the World Health Organization frequently finds himself confronted with a special educational problem—himself. He must, first of all, re-educate himself to the plain fact that many accepted procedures may be completely wrong for villagers in Afghanistan or desert wanderers in Egypt. Such a re-education involves daily experiences with cultural anthropolgy as well as sociology and agricultural routines.

As a general rule, the sanitary engineer, like most other technical employees of W.H.O., works closely with a trained counterpart who is a citizen of the host country. W.H.O. personnel are working in the host country at the invitation of that country's government. Through such counterpart officials and other trained citizens, the knowledge and the techniques of environmental sanitation can be spread to local levels and eventually to large segments of the population.

The scope of this tremendous ideal of health for all peoples can be seen from a large map that hangs in W.H.O. headquarters in the Palace of Nations, Geneva, Switzerland. The world is marked off into six large regions, each of these regions having an area office of W.H.O. All six regions have urgent public health problems clamoring for the attention of engineers, medical personnel, and other professional health workers. What are these problems? Such things as bilharziasis (schistosomiasis) in Egypt, yellow fever in the Americas, malaria in Afghanistan, elephantiasis in Thailand, yaws in Haiti, tuberculosis almost everywhere. The need is virtually endless, but the budget is less than the amount allocated to public health work in several individual states of the United States.

The curative aspects of W.H.O.'s

work are but a small part of the organization's function. There are some 21 other basic activities. Of these, one of the most important is education. The constitution of W.H.O. provides that one function shall be "to promote improved standards of teaching and training in the health, medical, and related professions." Thus, around the world, W.H.O. personnel are constantly teaching at the professional level in large universities as well as at the level of the simple villager in the less developed countries.

These two extreme levels of teaching, as well as the stages in between, are an important part of W.H.O.'s work in Egypt. This country, old in its history of engineering achievement, houses the regional W.H.O. office for the eastern Mediterranean countries in the large city of Alexandria. This city of a million people, however, is comparatively young by Egyptian standards, for it was founded by Alexander the Great in 342 B.C.

Some Public Health Problems in the Eastern Mediterranean Area

More than 5,000 years ago the government of Egypt began to keep records of the annual flood level of the Nile River—and an ancient Nilometer, constructed to record this data, still may be seen at Asswan, close to the southern border of Egypt. For just about that many years the statues of the gods at the nearby temple of Abu Simbel have kept watch over the waters of this lifegiving river as it enters Egypt on the long route from its sources in Ethiopia and central Africa to its outlet in the Mediterranean Sea.

But the days of the Abu Simbel statues may be limited, for, if the new high dam near Asswan is actually constructed, this ancient temple will be inundated. And even though the statues themselves may be moved and saved, the waters covering the beautiful old temple will emphasize the basic need of this dry, desert country of the Eastern Mediterranean—water. With the coming of the dam to store additional Nile water that is now wasted in the run-off into the Mediterranean Sea, there will come inevitably an increased need to attack and make progress in handling the related engineering and public health problems.

These problems are the familiar ones of simple environmental sanitation, adequate water treatment and sewage disposal, and reasonably adequate medical care, especially for the poor fellahin who till the soil and work in the irrigation ditches. These rural villagers who cannot avoid getting into the canals during their daily work (for much of the agricultural land of Egypt is used on a year-round irrigation basis) present one of the most pressing public health problems of this area.

More than half the population of Egypt is infected by the snail-borne bilharziasis (also called schistosomiasis). Its cost to the country is estimated to be some $200,000,000 annually. This debilitating disease is caused by parasitic worms that enter the human body by penetrating the skin. The female worm, after maturing in the human body, lays eggs. Some of these eggs, expelled with human excreta, find their way into canals and irrigation ditches. Once in the water they burst, and the freed miracidium, or undeveloped embryo, may enter the body of a snail, a special type prevalent in the canals. After living in the snail's body for about a month the embryo succeeds in reproducing about 200,000 developed larvae. After leaving the snail, these cercariae swim about in the water and find their human victims among the people who must work, bathe, drink, or do the family laundry in the canals. So it has been for at least 40

centuries in Egypt, for eggs have been found in Egyptian mummies that date as far back as 2000 B.C.

This problem of controlling and perhaps, eventually, eradicating bilharziasis is one of the many urgent health tasks now being attacked by the W.H.O. in the Eastern Mediterranean region.

Other Projects

A large variety of activities is under way in these countries. Projects to assist with tuberculosis control are in progress in Aden, Cyprus, Egypt, Ethiopia, Iran, Iraq, Israel, Jordan, Lebanon, Libya, Pakistan, Saudi Arabia, Somalia, the Sudan, and French Somaliland. Similarly, projects to help control malaria, bilharziasis, hookworm, eye diseases (especially through fly control), leprosy, cancer, and venereal infections are active in the countries of this area which have expressed a desire to work with W.H.O.

Many projects look toward training leaders for the future—projects in the fields of medical and nursing education, sanitary engineering, industrial health, public health education and administration, school health programs, and hospital administration. Education in public health practices is one of the most pressing needs of these 16 countries of the Eastern Mediterranean. This large area, with its center of activity at the regional office in Alexandria, presents examples of fine, modern public health installations in some of the large cities. On the other hand, the rural areas frequently lack all of the facilities that are considered reasonably necessary for the health of the residents.

There is much hope for improvement in Egypt through two processes now at work: the development of sound environmental sanitation practices and the spread of education. It is anticipated that the latter process, spearheaded by the University of Alexandria's professional training in sanitary engineering, may radiate out into many other countries of the area.

Public Health Education in Egypt

In cooperation with W.H.O. and the United States' I.C.A. program, the government of Egypt is pushing the educational work in attacking public health problems. The government's interest ranges from the village level, particularly with children in the public schools, upward to professional training at the Universities of Cairo and Alexandria.

Representative examples of this government concern for public health education are found in two current W.H.O. projects. At the level of the agricultural villager, the fellah, the Qalyub Health Demonstration Center at Qalyub Village, near Egypt's capitol city of Cairo, attempts to show the villagers simple public health practices. These, of course, include basic environmental sanitation procedures that contribute to everyday healthful living.

At the university level, the large University of Alexandria (with about 13,000 students) is developing and expanding its 5-year course in public health engineering and is opening related courses at various educational levels at the High Institute of Public Health. In addition, a Sanitary Engineering Experiment Station is being developed. Although the present University of Alexandria was founded only 15 years ago, in 1942, the ancient city was famous for its great library of some 700,000 volumes (or rolls), its museum, and such scholarly achievements as Euclid's *Elements of Geometry* and Eratosthenes' measurement of the diameter of the earth.

With the decline of Rome, Alexandria entered a period of decadence. Almost all of its great educational in-

stitutions were destroyed. The adjoining Canopic mouth of the Nile silted up, and Alexandria became a sleepy little city on the Mediterranean. Only after the Second World War did its vigorous rebirth really get under way. The urgent need for industrialization was recognized. With increased scientific interests came a new and urgent appreciation for better public health facilities and education.

The University of Alexandria now looks forward to the prospect of becoming a training center in sanitary engineering and public health education to serve the people of the entire eastern Mediterranean area. The W.H.O. has participated with the University in its program of expanding and enriching the sanitary engineering curriculum by providing visiting staff members and by assisting in the procurement of books and equipment. The High Institute of Public Health, located near the University, will be a part of the training center; its first classes began in September, 1956. In addition, the government of Egypt has created an Institute of Fundamental and Applied Research in Sanitary Engineering. This Institute, too, is located close to the engineering buildings of the University.

Since no similar facility exists in the Middle East (with the exception of certain courses of study at the American University of Beirut in Lebanon), it is expected that this center can fill the need for training Arab students within the cultural framework of their own countries. The practice in the past has been to send students to Europe or the United States for graduate and, even, undergraduate study. Some of the students, when they have completed their degrees, have not wished to return and, in many cases, parts of their training may not be applicable to their home situations.

The enrollment at the University of Alexandria for the school year of 1955–56 totalled approximately 13,000, with 1,753 students enrolled in the five years of study required for engineering degrees. In 1955–56, however, only seven students were enrolled for the degree of Bachelor of Science in Municipal and Sanitary Engineering. Consequently, efforts are now being made to reach prospective students throughout the Arab countries.

This degree in Municipal and Sanitary Engineering is awarded upon the satisfactory completion of a 5-year technical curriculum in the School of Engineering. Students receiving this degree have spent their final two years in a separate department for municipal and sanitary engineering. The previous two years of study were taken in conjunction with civil engineering students, and the first year, known as the preparatory year, was devoted to general engineering. The separate Department of Municipal and Sanitary Engineering was developed because the regular civil engineering curriculum at this university places major emphasis on irrigation and structures.

At present the 5-year curriculum is composed entirely of technical subjects. No provision is made for courses in the humanities, languages (but most students already have a reasonable command of English and French in addition to Arabic, and English is the language of instruction in the School of Engineering), and related fields.

Immediate Needs

For Egypt, education at the professional level is only a small part of the answer. The people of the villages need education in public health practices immediately. In order to start meeting their needs the government of Egypt, assisted by W.H.O., has

been developing a demonstration area in a group of villages centered around Qalyub, near Cairo. Somewhat comparable to the county public health organization in the United States, this project includes demonstrational activities in nursing with visiting public health nurses; in sanitation, with engineers and sanitarians demonstrating modern practices in water treatment, sewage disposal, and education; in maternal and child health practices; and in local hospital administration.

One aspect of the child health program in this Qalyub demonstration area aims at complete control of trachoma within this limited area. Trachoma, a prevalent eye disease that may lead to blindness, is a serious problem in Egypt. Just before the seasonal outbreak of eye infections is expected, some 5,000 children of preschool age in Qalyub are given sulfa drugs over a period of several days. Antibiotic ointment is applied to the eyes of about 2,500 school children twice daily for two months. "Health committees," composed of the children themselves, assist with these applications. Small groups of these children are being followed up intensively to study the value of the treatments. And, not least important, intensive sanitation campaigns and fly-control measures are instituted in the participating villages.

The entire Qalyub project consists of demonstrational activities that are somewhat experimental but that are expected to be desirable and workable in meeting Egypt's public health needs. The facilities of this area are available to Egyptian institutions, such as the universities, for demonstration and instructional purposes.

Water is the Key

"From water," proclaimed the prophet Mohammed, "all life comes." And no citizen of Egypt wants to argue the point. The distribution of water is still controlled by the laws of the prophet, for in Egypt one lives always in the shadow of the past. The sanitary engineer in Egypt, as well as in many other parts of the world, must help to bridge the gap between the old and the new.

Through education at all levels he hopes to help lead the people from the centuries-old shadduf, or bucket-lift operated by human labor, to modern irrigation equipment. He wants to make available and bring the people to use a modern distribution system rather than to provide the family water supply by means of filling clay water pots from the canals or the Nile. In short, he aims at helping to introduce millions of people to modern medical miracles and modern engineering practices of all sorts.

And after he has tried to accomplish these miracles, has he in fact begun to accomplish the purpose for which 88 nations, some of them ancient and traditional enemies, banded together to form the World Health Organization? Insofar as he has succeeded in preventing preventable diseases, curing curable diseases, and providing more healthful environment, the W.H.O. worker has succeeded in helping millions of people become more productive and more capable of supporting themselves in today's world. It is the dream of the sanitary engineer and all his associates in the World Health Organization to make at least a dent in the stupendous program of trying to "promote and protect the health of all peoples" everywhere in the world today. Only an idealist would dream of attacking a program like this, but the idealist believes that such health-giving activities often pay off in the most practical terms both for people and nations.

EDUCATION FOR SANITARY ENGINEERING RESEARCH

BERNARD B. BERGER

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Presented at a Conference of the Sanitary Engineering Committee No. 3 and the Applied Hydraulics Committee No. 5, 65th Annual Meeting of ASEE, Cornell University, Ithaca, New York, June 20, 1957.

Recommended by the Sanitary Engineering Committee

The broad challenges to sanitary engineering recognized a decade ago are now being felt by all elements of the profession—consultants, educators, industry, and public agencies. Ten thousand U. S. communities are experiencing air pollution; the urgency of the need for a practical method of disposing of radioactive wastes becomes even more acute as the first commercial nuclear power reactors approach completion; the revolutionary trends toward centralized preparation and national distribution of pre-cooked, non-sterile foods are placing increasing responsibilities for public health protection on industry and government; the acceptability of synthetic organic chemicals in drinking water supplies is regarded with less equanimity than formerly, as the chemical industry continues its growth and its competition for regional water resources. Each example cited represents a complex of problems whose solutions require new knowledge and improved techniques.

The opinions offered here are based on experience in research administration at the Robert A. Taft Sanitary Engineering Center and on discussions with scientists and engineer colleagues at the Center and elsewhere. These comments are directed to the preparation of sanitary engineers for research, collaboration between engineers and scientists, and regional problems as focal points for university research.

Preparation of the Sanitary Engineer for Research

The profession is being forced to evaluate current research training and performance as essential elements in the total task of improving the sanitary engineer's ability to cope with the new problems. In this, the profession is subjecting itself to the well-known "agonizing reappraisal." The latest evidence is to be found in the symposium of seven papers contained in the April, 1957, *Journal of the Sanitary Engineering Division, ASCE.* Each article focuses attention on some phase of the sanitary engineer's dilemma: how to enable the engineer to deal with problems of the environment for which conventional sanitary engineering training is inadequate.

We are confronted with the report that in 1950 only 100 sanitary engineers were engaged in research (2). In the period 1951–1956 inclusive,

only 43 doctoral degrees in sanitary engineering have been awarded to U. S. nationals (3). The low production rate of research sanitary engineers reflects the small number of undergraduate students selecting sanitary engineering as their profession.

Motivation of undergraduates toward sanitary engineering is handicapped by inadequate salaries (4) and ignorance of professional opportunities. However, the challenging nature of sanitary engineering problems may in itself be used as an inducement for research-minded engineering students to enter this field. We can assume that if he is oriented properly, he will find sanitary engineering research strongly competitive with other engineering branches as a useful and rewarding career.

The reservoir of potential research workers is not limited to those completing undergraduate work in sanitary engineering. The great sanitary engineer, Allen Hazen, was trained as a chemist. (Conversely, the great biologist, G. C. Whipple, received his training in sanitary engineering.) The chemist, aquatic biologist, and microbiologist have always been essential in the evaluation and control of environmental health problems.

At some institutions, chemists, physicists, and biologists can qualify as engineers by taking a basic core engineering course (5). Several prominent schools accept chemical and mechanical engineers as candidates for sanitary engineering graduate training as readily as they accept civil and sanitary engineers (6). McKinney (7) has expressed his opinion that the chemical engineer is actually better equipped than the sanitary engineer to undertake studies on the control of industrial wastes.

This may represent an extreme viewpoint; however, further evidence of what is in fact a broadening and reshaping of the scope of the sanitary engineer's field is noted in the recent decision by the American Sanitary Engineering Inter-Society Board to give certification to qualified chemical engineers. In view of the exceedingly varied problems that must be solved, it is not surprising that a wide spectrum of backgrounds may be appropriate as preparation for significant research. Actually one may wonder whether sanitary engineering educators have purposefully and effectively tapped these areas of undergraduate work as an important source of research personnel.

The contribution that may be made by various scientific disciplines to the solution of sanitary engineering problems indicates the obvious importance of basic science courses in the training of the sanitary engineer. The same general need prevails throughout engineering. A widely accepted expression of this need in undergraduate training is contained in the Society's Report on the Evaluation of Engineering Education (8). The sanitary engineering situation is perhaps even more demanding than other engineering fields because it is concerned with the impact of the environment on the organism—in effect, a merging of engineering and biology.

Many of us—in education and out—are persuaded that specialization in sanitary engineering is best developed on a broadened and intensified foundation of basic sciences and applicable engineering principles. The practice of this kind of engineering would be obtained most usefully through a combination of graduate study and work experience. Even with more generalized engineering preparation, the problem of specialization may not be resolved easily. The question still remains: should the selection of basic courses depend on the environmental phase—air, water, radioactivity, food—

in which the sanitary engineer proposes to work?

The difference in views of what should be presented to the student is illustrated by the specific preferences of the persons in charge of the major research areas at the Sanitary Engineering Center. In air pollution control the student should have knowledge of meteorology, principles of unit operations and processes, and physiology. In addition, he should be given a major course in air pollution, including sampling and analytical techniques, control, and legislation.

The student in radiological health should receive training in the use, handling, and measurement of radioactivity, supplementing a basic course in nuclear physics. He should also be informed on the shielding characteristics of various structural materials and on the effects of radioactive materials on strength and other structural properties. In food sanitation he should receive additional information on microbiology and biochemistry.

In the field of water supply and water pollution, the sanitary engineer undergraduate should have more mathematics, organic, physical, and biochemistry, and microbiology. Many of these subjects may be part of existing courses. However, the problem of reconciling these needs is obviously a formidable task for the educator.

While the degree of stress on basic science for the undergraduate may be debated, there should be no argument on the need for the strongest foundation in science and scientific method for the sanitary engineer in research. Adequate instruction in the sciences, in engineering principles and practices, and experience in the rigor and discipline of independent research would normally require at least the equivalent of a full doctoral degree. Post-doctoral research experience at the University should be encouraged for the gifted research sanitary engineer, as it has long been for other scientists.

Thoughtful commentators on the plight of the sanitary engineer emphasize the importance of the humanities and social sciences in supplementing the physical sciences required in the undergraduate course. An understanding of broad economic and social forces and of their influence in shaping the living and work environment is essential to intelligent planning of the engineering program. The sanitary engineer will render his most useful service when he foresees probable public health effects from emerging environmental factors, interprets these influences in terms of a desirable course of action, and obtains effective support for this action.

An awareness of the public health significance in environmental change should be the hallmark of the sanitary engineer. This is routinely displayed in evaluating the pollutional effects and treatment requirements of gaseous, particulate, and liquid materials proposed for discharge into the atmosphere or water course. However, these are familiar sanitary engineering problems. Beyond these situations we should be able to discern important hazards that might follow major changes in environment.

For example, we might try to foresee at this time the public health stresses, if any, that might be created when the St. Lawrence Waterway is completed and inland cities are converted to ports for transoceanic shipping. Or, we might predict the effects of the federal highway construction program on urbanization, with its attendant water supply and sewage disposal problems.

Already, we are confronted by questions on adequate sewage treatment in areas remote from water courses where only natural drainage ditches

are available for final disposal of treated effluents. These and many similar problems are either present or are imminent. The sanitary engineer oriented in the social sciences would be alert to subtle but important environmental influences on public health and well-being.

Skill in the art of communication is particularly important. Inadequate preparation has been emphasized in the Report on Evaluation of Engineering Education, which states: "The young engineer is handicapped by inability to convey ideas to others in a clear, logical and interesting manner, using correct and concise oral or written language." Any of us who have to review technical papers prior to publication would strongly support additional, rigorous training to help the research worker write more clearly. For that matter, any of us who have to present and defend budgets would be grateful for a greater facility in effective oral expression.

Collaboration Between the Research Sanitary Engineer and the Scientist

It is generally accepted that the sanitary engineer in research requires the collaborative efforts of his scientific colleagues. Occasionally this dependence is minimal, consisting only of consultation when difficult special situations are encountered. The development of a desirable cooperative enterprise might be greatly strengthened at most sanitary engineering research institutions.

The full contribution of science to sanitary engineering is far from having been realized even in the familiar problems of water supply and water pollution. One consequence is that sanitary engineering research is characterized by refinement of existing processes where paths have already been laid out, rather than by really fundamental advances. Although what constitutes a fundamental advance may be a matter of personal definition or preference, it would be difficult to point to more than a very few clear-cut "break-throughs" by sanitary engineers in the last decade, leading to novel and rewarding avenues of engineering practice.

The gap in communication between sanitary engineers and scientists in related fields has been mentioned by Faber (5), who stated that a huge backlog of scientific findings in chemistry, physics, and biology is now available to the sanitary engineer because research in these fields has forged out so far ahead of that in sanitary engineering. "Water chemistry, for example, lags far behind petroleum chemistry. As an illustration: inspection of the sanitary engineering literature has shown that the concept of 'activity coefficients' was not applied in water chemistry until late in the 1930's, many years after being widely used in the industrial research area."

This failure in recognition and use of important new knowledge probably exists in other areas. For example, in the familiar field of water supply and pollution, it might be of interest to emphasize further exploration of the following:

1. Bacterial mutation as it may contribute to biological oxidation of industrial waste.
2. Kinetics of chemical reactions in dilute solutions as it may contribute to knowledge of assimilation of wastes in streams.
3. Biochemistry as it may contribute to the specific identification and the measurement of trace concentrations of organic material in polluted waters.
4. Physical chemistry as it may contribute to improved control of chemical coagulation.

These are merely a few suggestions of specialized fields in which research engineers and scientists might improve their communication. The school of sanitary engineering, with its faculty and student research potential and its close proximity to other university departments, is in an ideal position to promote such collaborative studies. For the graduate student interested in research, the opportunity for cross-fertilization at the outset of his career should be particularly rewarding.

This idea is not novel. Some schools of sanitary engineering already use the resources of other departments to broaden and strengthen the sanitary research enterprise. Such practices can be expanded with considerable profit.

The initiation of collaborative research is probably handicapped by competition for the research effort of the small number of doctoral candidates in sanitary engineering and in other departments, and by the insufficiency of research resources in sanitary engineering schools. We may hope that these conditions will be changed when the present expanding school enrollment is reflected in the graduate school.

Federal grants to support research at sanitary engineering schools should be increasingly useful in attracting research-minded students, and in improving research facilities. The growth of interest in the PHS research grant programs in sanitary engineering is evident in the recent spurt in applications and in the amount of funds disbursed. The extent of this assistance may be expected to increase as a result of authorizations for research grants contained in the Federal air pollution control and water pollution control legislation.

The PHS has just initiated support of research fellowships in the field of sanitary engineering at the pre- and post-doctorate levels to increase the number of engineers and scientists qualified to undertake independent research. Grants for construction and equipping of health research facilities were authorized on a matching basis in 1956.

With the newer problems requiring solutions, the sanitary engineer must inevitably lean more heavily than before on the organic, physical, and biochemists, on the physicists, on fluid mechanicians, on microbiologists, and on many other specialists in the basic sciences. Current and foreseeable research involving synthetic organic chemicals in water, air, and food, radioactive materials, and more intelligent use of microorganisms in waste destruction or reclamation point to the ascendance of the team of scientists as a basic research unit.

Purpose and direction will be provided by that member of the team who commands the greatest respect of his colleagues for his ability and scientific judgment. The minimum contribution of the sanitary engineer to the team's effectiveness should logically be the application of the research findings to the design of control works. In addition, one should expect him to provide sound perspective and to be an effective catalyst and coordinator in all phases of the research enterprise.

Actually, the sanitary engineer's contribution could be even greater. Since he uses science and engineering to control environmental conditions affecting man's health and well-being, his training is suited to accepting comprehensive responsibility for major research tasks. Therefore, the sanitary engineer who has received intensive training in the sciences and who has had rigorous experience in research could be ideally qualified to provide effective team leadership.

Research on Regional Problems

While the particular interest of educators may dominate the university research program, the influence of local problems will frequently be reflected in the research tasks undertaken. This is not surprising, because the school is often considered to be a regional resource and its staff are expected to provide expert consultation on problems of the area.

It is likely that with intensified environmental stresses in the future, the pressures put on the schools to constitute foci of technical competency on these problems will become even greater than at present. Since regional problems differ, it is conceivable that schools may specialize more than at present in their selection of sanitary engineering problems.

An example of a regional problem which may serve to focus the sanitary engineering research program is the following:

The upper portion of the Ohio River system offers a variety of very difficult and significant problems. These waters, initially of very high quality, are impounded in federally constructed reservoirs, and are polluted by acid mine drainage, industrial inorganic and organic wastes, and raw or incompletely treated sewage from a number of communities.

In the course of its flow the stream is used as a source of industrial water supply by a great many industrial plants, and is a source of drinking water for many communities in Pennsylvania, West Virginia, and Ohio. Among the problems of research interest are the following:

1. Determination of adverse effects of impoundment on water quality.
2. Determination of the effects of synthetic organic chemical wastes on reaeration rates and on stream self-purification rates.
3. Formulation of flow diffusion patterns of wastes discharged into pooled waters.
4. Determination of effects of increased temperatures resulting from discharge of industrial cooling waters on stream biota and self-purification.
5. Determination of effects on self-purification capacity when a freely flowing stream is converted to a series of navigation pools.
6. Determination of effects of intermittent flows produced by hydroelectric power plant operations on stream self-purification characteristics.

Summary

In summary, the following points are stressed:

1. Because scientists of all kinds play an essential role in sanitary engineering research, educators could try more aggressively to orient student scientists and engineers toward careers in this field.
2. Preparation for sanitary engineering is best developed through a disciplined program of undergraduate study in the basic sciences—mathematics, chemistry, physics and biology—and in applicable engineering principles. Instruction in the sanitary engineering practice may be gained most usefully through a combination of graduate study and work experience.
3. Educators should promote collaborative research with university science departments to improve opportunities for bringing into the sanitary engineering field basic new knowledge from other areas.
4. As far as feasible, educators should relate the university research program in sanitary engineering to significant problems of the region.

The variety and range of his tasks force the sanitary engineer in research

to possess knowledge encompassing literally the whole gamut of the sciences as well as fundamental engineering principles applicable to many fields. This scope of knowledge is a measure of the responsibility of the educator in preparing sanitary engineers for research careers.

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C. E. DIVISION NOMINATIONS

The Nominating Committee of the Civil Engineering Division has submitted the following nominations in accordance with the newly adopted bylaws of the Division:

Representative to Council (1958–60)—B. A. Whisler
Chairman (1958–59)—R. C. Brinker
Vice Chairman (1958–59)—L. K. Downing
Secretary (1958–61)—G. Reed Shaw
Director (1958–59)—C. K. Wang
Director (1958–59)—R. E. Stiemke
Director (1958–60)—E. E. Johnson
Director (1958–60)—A. T. Granger
Director (1958–61)—W. S. LaLonde
Director (1958–61)—P. F. Keim

Further nominations from the membership will be accepted prior to the mailing of ballots, not later than March 30th. Nominations should be mailed immediately to the Chairman, B. A. Whisler, Pennsylvania State University, University Park.

MECHANICAL ENGINEERING IN THE PROCESS INDUSTRIES

H. N. MEIXNER

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Presented at the Annual Dinner Meeting of the Mechanical Engineering Division of ASEE at Cornell University, June 19, 1957. Recommended for publication by the Division.

"Increasingly, I find myself in sympathy with breaking down the barriers between undergraduate curricula. Non-specialization at the B.S. level seems quite appropriate to me, at least for a large proportion of engineers in the process industries. For the sake of those who do not share this view, however, I shall endeavor to confine my remarks to mechanical engineering."

At the outset, let's look briefly at the nature and scope of the process industries. It has become quite difficult to define the boundaries of the chemical industry. Success has lured companies from other industries into its orbit: petroleum producers are now important chemical manufacturers; paper companies, rubber companies, even manufacturers of electrical machines and farm equipment are chemical producers today.

The industry is still relatively young, yet its sales last year topped the 24 billion dollar mark. For engineers it has two characteristics which make it of special interest: It has a very high growth rate, and it is what I would like to call a technical man's industry. The 12,000 plants of the industry today are located in every region of the United States. Since 1939, production of industrial chemicals has grown at an average rate of about 10% a year, compared to 3% for all industry. Continued growth at a rate greater than the rest of industry is predicted by authoritative studies.

The large number of technical people employed in the chemical business is both a cause of this rapid growth and a result of it. For 35 years, research and development programs in the chemical industry have been in the forefront of industrial research. In 1956 the National Science Foundation estimated that 34% of the 62,700 scientists and engineers employed by the chemical industry in January, 1954, were engaged in research and development.

Chemical companies largely create their own markets by developing new and superior products for old uses, like nylon for stockings. They also develop products which make possible uses never thought of before, such as polyethylene for squeeze bottles or super-pure silicon for transistors.

All of my experience in the process industry has been with the du Pont Company. Although du Pont is the largest corporation in the industry, it has only about 8.3% of the chemical and allied products business in the United States, and competes with over 10,000 other companies. Du Pont produces more than 1200 major products and product lines. Accordingly, I believe it provides an excellent case study in the scope of engineering work carried out in the process industries.

Let's have a look at the organiza-

tion of the du Pont Company to get a better picture of how this engineering is carried out. As you probably know, du Pont is a highly decentralized organization. Eleven separate industrial departments operate the Company's 75 manufacturing plants located throughout the United States. These autonomous departments also conduct their own research and selling operations. Each of these departments does some engineering work in such diverse activities as research, development, production, maintenance, and technical sales.

Research and development may be carried out in large laboratories located in Wilmington or at laboratories or semi-works facilities at the plants. Plant process development, production, maintenance, minor design, and construction are carried out at plants with as few as 40 employees located far from centralized facilities or at large plants with as many as 3000 employees located either near or far from centralized sources of talent and facilities. With so many kinds and types of products developed, manufactured, and used under such a variety of circumstances, the technology involved in the engineering done obviously runs the whole gamut of the physical and engineering sciences.

So much for the eleven profit-producing industrial departments. In du Pont there are also fourteen auxiliary departments which provide services to the industrial departments. The largest of the auxiliary units is the Engineering Department, which employs almost one-third of the Company's engineers. The Engineering Department is highly integrated, with operations ranging from research to construction work.

It maintains three laboratories devoted to developing basic information for future designs and facilities which will improve return on investment and product quality. These are the Engineering Research Laboratory, the Radiation Physics Laboratory, and the Mechanical Development Laboratory. The last of these, employing primarily mechanical engineers, designs, builds, and tests prototypes of special-purpose machines in addition to conducting mechanical and electro-mechanical research. The Engineering Department handles the bulk of the Company's design and construction. In the past ten years, it has undertaken approximately 1500 major projects accounting for over 800 million dollars.

In addition, the Engineering Department has handled projects aggregating one and one-third billion dollars for the U. S. Government and two du Pont licensees. Supplementing these activities, the Engineering Department maintains some resident engineers at many plant locations to assist operating departments in reducing manufacturing costs and improving product quality. It also provides from a central source, a wide range of engineering consulting services.

This background on engineering at du Pont has been recited in order to give you an idea of its vast diversity. In this complex industry, we have all types of mechanical engineering from research and development through design, construction, production, maintenance, and sales. Recognizing that a large portion of the technology and manufacturing operations in the industry involve essentially physical rather than chemical change to the material being processed, let's look at some examples.

In one area of the chemical industry, the concept was developed that size, shape, and polarity of molecules largely determine their behavior in finished products. This concept revealed the type of molecular architecture necessary for such varied products as flexible film; hard, machinable

plastics; polyesters to replace metals; oil-soluble as well as oil-resistant rubbers; and fibers finer than hairs but stronger than steel.

When Dr. Carothers, a chemist, pulled the first strand of nylon (the first truly synthetic fiber), he created a challenge for the engineers. Machines had to be developed and built that could spin this polymer so that it would be uniform in quality and economical to produce. They had to handle strands of fiber for filaments finer than a spider's web and at speeds faster than a mile a minute.

Many steps of mechanically working or manipulating of the fibers are required to help develop the physical properties desired. Different properties are needed, depending upon the end use of the product, such as, for example, fine hose or parachute cloth or tire cord. Each of these also requires special types of packaging to meet the requirements of the users.

I have been talking about the obvious mechanical aspects of the process, but half of the investment in the facilities for making nylon is involved in making the stuff that Dr. Carothers had in his test tube. This so-called chemical part of the operation also requires a surprisingly large amount of mechanical equipment: agitators, reactors, pumps, heat exchangers, control devices, conveyors, and many more items of that sort. Problems involved in these areas are primarily those of the mechanical engineer.

In another area of the chemical industry, the original work of Haber on the fixation of atmospheric nitrogen opened up a large area of difficult problems for mechanical engineers. The supply of available nitrogen in the earth is limited and inadequate for the fertilizer required in the production of food. Improved methods of using the available nitrogen in the earth brought only temporary relief.

When a process was conceived and developed whereby the nitrogen in the air about us could be fixed and put to use, vast quantities became available both for agricultural and other purposes. In the hands of the process industry, this vast supply of extra nitrogen was put to use in such diversified ways as treatments for steel, explosives, better dyes, and a wide range of drugs for the control of disease.

To make this process practical, the talents of mechanical engineers were taxed to the utmost. Their problems involved development of compressors to operate reliably and safely at 1000 atmospheres pressure in sizes of several thousand horse power, converters in which the pressure problem was compounded by temperatures of 450° C., and other complications too numerous to mention. Mechanical engineers met these challenges.

In the growing chemical industry, mechanical engineers perform most of the types of work that they do in any other industry. The added complications of the severe physical conditions in which the chemical industry operates make the normal functions of research, development, design, production, maintenance, and sales especially interesting.

Once a frontier has been bridged into the unknown and a new product has been developed through research, we again head into the unknown when the plant has to be designed to produce this product. As I have previously mentioned, du Pont does all its own major process design through the Engineering Department. This is done for several reasons: speed, economy, and protection of know-how. The work involves design of process machinery and equipment, such as pressure vessels and the piping necessary to transport fluids.

To do it satisfactorily requires a

knowledge of heat transfer, fluid mechanics, strength of materials, and basic physics and chemistry—the tools of the mechanical engineer. In addition to the engineers who plan this special process equipment, the design of many components is carried on by specialists in the fields of instruments, power, refrigeration, air conditioning, heating and ventilating, pumps, seals, bearings, and the solution of special mechanical problems, such as complex stress analysis.

Design is followed quickly and often almost concurrently by construction. Mechanical engineers appear here in the supervision of the various crafts necessary to new plants, including installation of equipment and its start-up.

Once the plant has been placed in operation, it falls to mechanical engineers, through the plant engineering groups, to maintain that plant in an economical operating state, to supervise the necessary maintenance, to devise solutions to plant problems, to assist in planning for future expansion. Maintenance of complex chemical plant equipment in its rugged service frequently requires mechanical engineering of the highest order if it is to be done with the necessary safety and economy. Maintenance engineers supervise foremen and the various mechanical crafts engaged in maintenance work. They often do design for changes and additions of moderate magnitude and supervise the construction work.

In many of the plants whose operations are largely mechanical, mechanical engineers also serve as production supervisors. These men maintain employee relations, production output, quality, and safety, but while doing so, keep an eye open for ways to improve the equipment and machines.

An adequate engineering background and knowledge, appropriately planted among production people, has often made possible some of the most creative solutions to difficult problems and, at the very least, helps materially in getting the proper specialists assigned to problems which operating people cannot solve. Mechanical engineers are successful, often essential, in those sales activities where their special knowledge and training can help the customer in his use of the Company products.

Thus we see how the chemical industry can and does use the services of many mechanical engineers having a variety of backgrounds and talents. These engineers may specialize in any of the fields I have mentioned, or they may obtain broad experience in many of them. In either case, they can make a major contribution to the process industries.

May I remind you, therefore, that mechanical engineers are needed in all phases of industrial activity in the process industries, including design, construction, operation, and maintenance. In du Pont there are over 1700 mechanical engineers, about one-quarter of the total number of engineers in the Company. In the Engineering Department, one-third of the engineers are mechanicals. I have tried to give you a brief but comprehensive look at what they do. The work that they will have to do in the future staggers the imagination. What they *will* do will doubtless surpass all expectations.

THE NEW LOOK IN HEAT POWER: UNDERGRADUATE STUDY

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Presented at the evening conference of the Mechanical Engineering Division, June 18, 1957; recommended for publication by the Division.

These are days of an academic revolution in engineering education. It is a revolution that is well organized, universal, and, by historical standards, rather passive. Now that some of the hysteria has died away, we are examining the proposed changes with a rational approach which is commendable. (Or can a revolution without hysteria fairly be called a revolution?)

It is my mission, however, to express my views on the directions our heat power courses should follow, and it is my earnest desire to say something controversial. It is from controversy that good ideas often spring.

To examine one's area of teaching with an intent to improve it requires that the examiner stand back from his work as a painter does; one must divorce himself from any emotional bias, and be as objective as possible. Many people are willing to make changes in curricula as long as the change increases the amount of study done in their field. To be truly objective, we must be prepared to reduce course time or even to drop one of our own courses from the required list if our conclusion is that this would build a stronger curriculum.

Now that we are in an objective but jolly frame of mind, let us outline our attack on this problem. Our goal is to suggest ways in which the teaching of undergraduate heat power may best fit into the engineering curriculum of the future. To do this we must first explain why we teach heat power. Secondly we must examine curricula in various institutions to determine what is done at present. Finally we must purge our current courses of non-essentials and outline a positive plan of action. Certainly if we find existing programs meet with our requirements for an idealized curriculum we need not apply our third step.

My preference at this point would be to skip item one and go directly to item two. But alas, it is imperative that we establish why heat power courses are taught and what undergraduate preparation we expect a student to obtain in this field.

The "Report of the Committee on Evaluation of Engineering Education" June, 1955, offers a possible answer. The technical objective of engineering education, this report says, "is preparation for the performance of the functions of analysis and creative design, or of the functions of construction, production or operation where a full knowledge of the analysis and design of the structure, machine or process is essential. It also involves mastery of the fundamental scientific principles associated with any branch of engineering including a knowledge of their limitations and of their applications to particular problems."

From experience with engineering problems of this nature, one concludes that among the areas of science upon which engineering relies are certain ones which can be clas-

sified as heat power. Using the list of six engineering sciences suggested by the Committee on Evaluation, the sciences of thermodynamics and heat-mass and momentum transfer could be considered in this domain. With these sciences as the tools, the student should be instructed in their use, for this is what distinguishes the field of engineering from that of physics. The Evaluation Committee describes this area as "Education directed toward the creative and practical phases of economic design, involving analysis, synthesis, development, and engineering research."

One might offer other reasons for the existence of a heat power faculty. There is a liberal arts nature to thermodynamics that should not be overlooked. This lies in the philosophy and logic which it employs.

These reasons seem sufficient to justify the inclusion of undergraduate heat power courses in an engineering curriculum. The extent of the instruction given a student will vary depending on the students field of specialization. There will be some students who will only take a single course in heat power, perhaps as a service course. This group should be capable of at least having an appreciation of the problems confronting the engineer working with heat and thermodynamics. The ability to discuss problems and read in these fields should also be helpful to this student.

At the other extreme are the students who will work in the field of heat and thermodynamics in industry or study it extensively in graduate school. These people should have gained a firm platform from which to branch into the many areas of heat and thermodynamics. This will require a basic course in thermodynamics and some advanced or applied work before graduation.

Now that we have convinced ourselves that we should teach subjects in heat power, let us examine how this job is being done in schools throughout the country. The area of heat power seems to be divided into the following groups; thermodynamics, heat transfer, applications or professional courses, and the service courses.

For this study, the author examined the catalogs of thirty-two colleges. These schools were chosen as arbitrarily as one would in simply reaching for thirty-two catalogs from the library shelf. This turned out to be a good way to sample, as the list includes technical schools, state universities, privately endowed schools, and municipal universities. Caution was exercised in using catalogs for 1955 or later. Most catalogs were for the current year.

Tabulations were made of courses in heat power taken by mechanical engineering and electrical engineering students in the several schools. Only courses which were required for all mechanical or electrical students were listed. This resulted in some difficulty as some universities offer heat power options. Students taking a heat power option are required to take more heat power courses than students in other options. For this survey, only courses required for students in all options were considered. The results of this survey for mechanical engineering students are summarized in the following table:

Elementary course in heat power engineering:	
Number of schools requiring	5
Thermodynamics. Number of schools requiring:	
No courses	1
One term	0
Two terms	25
Three terms	6
A sophomore course	2
A senior course	5

Heat transfer. Number of schools requiring 16

Number of schools offering:

As an undergraduate course	24
Only as a graduate course	4
No course offered	4

Applied or professional heat power courses:

Number of schools requiring:

No course ...	10 (three offer heat power options with required applied courses)
1 course	8
2 courses	5
3 courses	5
4 courses	3
5 courses	1 (a five year program)

Average number of courses required ... 16

Total number of heat power courses required:

Number of schools requiring:

No course	1
1 course	0
2 courses	3
3 courses	7
4 courses	8
5 courses	3
6 courses	7
7 courses	2
8 courses	1 (five year)
Average number ...	4.6

The average school requires two terms of thermodynamics in the junior or third year accompanied by a single laboratory. They may require a heat transfer course (about 50% do), but in any event there will be three other courses in heat power required. There is usually one or two laboratories in heat power as well. In cases where heat power options are offered, there is considerably more heat power required. About one fourth of the universities studied had some form of heat power option available. Only 5 of the schools require an elementary heat power course, given in the sophomore year in each case.

The professional courses go under numerous titles. By categories, the number of schools requiring courses were: internal combustion engines, 12; turbines, 4; power plants, 13; heating, ventilating, airconditioning and refrigeration (in various combinations), 9; courses called "engines" or "applied heat power" are required in 5 schools.

In one college the thermodynamics is taught with fluid flow. One university does not specifically require any heat power course for its mechanical engineers, although the electives are restricted so that a course in heat power will probably be taken. Another interesting feature of the study was that although the "Evaluation" report speaks of "heat, mass and momentum transfer" only two schools mention mass transfer in their outline of the heat transfer course.

In an effort to evaluate what is being done in the way of heat power in the area of service courses, the electrical engineering curricular of these same thirty-two schools were studied. The number of schools and the required number of heat power courses for electrical engineers follow:

No heat power required	1 school
One course required	19 schools
Two courses required	12 schools

One of the schools requiring two courses specifies a one term sophomore course in elementary heat power followed by a single term thermodynamics course in the junior year. Eight of the schools give one or all of their thermodynamics courses in the senior year. However, the typical engineering school requires a single thermodynamics course given in the junior year, which is accompanied by a heat power laboratory.

Several interesting things appeared in the study of service courses. Although the evaluation committee felt that heat transfer was nourishing for all engineers, regardless of field, only one of the schools has seen fit to require it of their electrical engineering students. In one school, the first

of two thermodynamics courses for electrical engineers was taken in the physics department and the second in the mechanical engineering department. Another institution allows the single required thermodynamics course to be taken in either the mechanical, chemical engineering or physics departments. These students may elect to take a second term of thermo given in the mechanical engineering department.

These then are the things that the colleges are presently doing in the area of heat power for the undergraduate. Of course it should be no surprise to anyone that the term thermodynamics or applied thermodynamics has different meanings in different schools.

It is at this point that I leave the realm of facts and figures and seek an answer to the third objective: to purge our courses of non-essentials and outline a heat power program for the future. These opinions are based upon observations, catalogue descriptions and a knowledge of the undergraduate heat power text books in use. It is the thermodynamics course that forms the basis for a student's future work in heat power, whether that is in the form of more advanced courses or of work in the field. For many students the thermo course is the only heat power course taken.

Consequently, the first course in thermodynamics for any student should (1) establish a thorough understanding of the first and second laws, and (2) endeavor to stimulate the student's interest in the field of heat power, with the hope that some of the better students will choose heat power as their major field.

It is my belief that both of these goals can be accomplished best by turning our attention more toward what might be called the classical forms of thermodynamics. Thermodynamics is logical and precise. It has been my experience that the students are hungry for just such a challenge.

All too often, thermodynamics courses endeavor to start the student solving problems as soon as possible. This results in introductions of thermodynamics of gases and cycles before they should be introduced, and reduced emphasis on the logical development of thermodynamics as a science.

An eminent faculty member of a large school told me recently that in his school, where many sections of thermodynamics are taught simultaneously, the effort seems to be to prepare all of the sections for the same final exam. This requires that the students spend their time in problem drills, so that at the end of the term all of these actions will have had equal preparation. This is hardly the way to inspire.

It is my opinion that most of our courses and many of the commonly used texts in thermodynamics have one or more of the following shortcomings:

1. Lack of rigor in deducing facts from the basic laws.

2. Failure to establish the concept of temperature in a logical manner.

3. Failure to give all connotations of the first law, rather than simply the conservation of energy.

4. A weak treatment of entropy and the second law. Entropy is frequently stated as a definition, and posed to the student as something mysterious that even the instructor can't understand. Often entropy is introduced before the Carnot cycle and frequently entropy is used to show that the efficiency of the Carnot cycle is solely a function of temperature. The second law is delayed until the last third of

the course and rarely applied to problems.

5. Using a particular pure substance such as an ideal gas to prove a thermodynamic fact then simply extending it to all substances.

6. Leading the reader even to think that the only good thermodynamic substances are vapors and gases. Are solids to be denied obedience to the first law?

7. Studying state changes in ideal gases one process at a time; again failing to use a general treatment.

8. Simply using Joule's experiment to indicate that the internal energy of an ideal gas is a function of temperature only. As Joule used real gases, for which this is not so, we are teaching a falsehood.

9. Failure to use the first law for a consistant attack for problem solving. For example, some texts solve heat exchanger heat balances as if they had completely forgotten the first law.

10. Over-emphasis on cycle analysis, and here too the first law seems to have been forgotten.

11. The use of "total heat" in psychrometry, and the fear of using moles in mixture calculations.

12. Drawing irreversible processes on T-S and P-V diagrams as if the path of the process was known.

I feel that a good thermodynamics course should consist of a thorough understanding of the basic laws, an attempt to solve problems in a general way without depending solely on gases and steam for working media, and a knowledge of the limitations of the theories where limitations are imposed.

In the thermodynamics course, applications should be introduced to stimulate interest, and to show the student how the laws may be used practically. Time should not be used to cover applications which will be seen at a later time.

For example, is the first course in thermodynamics the place to draw turbine velocity diagrams? This, it would seem, depends on what is to follow, but it is extremely doubtful whether the usual treatment found in thermodynamics books on this subject is worth the time.

It is my belief that the historical development of thermodynamics is a good way to stimulate interest. For example, the first law can be introduced by describing Joule's experiment and then drawing conclusions regarding the first law from the results. The Carnot Cycle becomes far more interesting if we recall the era of the caloric theory. The subject can be introduced in the manner of Carnot in "Reflections on the Motive Power of Heat," noting the obstacles of the erroneous thinking of that era. With a little effort, we may have a new course in humanities.

New Program

With these comments as a basis, permit me to propose a program in heat power engineering. The mechanical engineer would have a single term of thermodynamics with a classical flavor. From here he may be required to take a course in heat and mass transfer as suggested by the Evaluation Committee report. All professional or advanced courses in heat power would then be taken on an elective basis, with faculty guidance and approval of course. These professional and advanced courses might be rather varied, representing any phase of heat power engineering than anyone on the faculty might wish to teach.

Of course there is no need to say that these professional courses should not attempt simply to teach design techniques nor descriptions of equip-

ment. These may not exist in ten years, and, in fact, may not exist at the time the course is being given. However, good applied courses can be devised to study machine processes using the laws of thermodynamics and, showing how tests and development are used to relate these to the real machine process.

The service course for the electrical or civil engineer would be a single term or semester in thermodynamics. There is no valid reason why it should be any different from the course given to the mechanical engineers. It is a fact that the first law of thermodynamics is identical for all fields. If it is possible to mix all fields in this course, I think that would be an advantage. It would reduce the feeling that this was simply a service course, taken by electrical engineers solely to satisfy a requirement in the college catalogue. Members of the various fields of engineering must work together in industry, yet are too often segregated in the university.

I have frequently referred to the Report of the Evaluation Committee, and sympathized with many of its proposals. I do not want to give the impression that I favor conformity just to become accredited. This is the road to stagnation. Fortunately, there are many non-conformists among us. One way to retain individuality in our own programs might be to allow greater freedom of electives for senior students.

The engineers of the future must apply thermodynamics to new forms of energy and to new methods of transforming it. We cannot anticipate what new problems he must solve. Consequently, he must study thermodynamics and heat power more intently and in a more general way than did the engineer of yesterday, if he is to serve his community better. The best preparation for this is not simply spending more hours in heat power courses. Rather, it requires greater intensity, a more rigorous approach, and a more generalized treatment. In short, a return to the classical in thermodynamics.

AERONAUTICS DIVISION TO MEET WITH IAS

The usual joint session of the ASEE Aeronautics Division and the Institute of the Aeronautical Sciences will be held January 29 or 30 in New York as a part of the IAS meeting. The program will consist of a four-cornered panel discussion of industry-education relationships, followed by a Divisional business meeting.

Speaking on the topic, "What industry needs from Engineering Education," will be Mr. Richard G. Bowman, Chief Engineer for Production and Experimental Aircraft, Republic Aviation, and Dr. Charles S. Draper, Director, Instrumentation Laboratory, MIT. Their addresses will be followed by a panel discussion led by representatives of industry and education. The session will conclude with a brief Divisional business meeting.

TEACHING KINEMATICS BY PROJECT SYNTHESIS

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Presented at a conference of the Mechanical Engineering Division, June 18, 1957; recommended for publication by the Division.

Kinematics has for years been regarded (by students especially) as the dregs of the mechanical engineering department. If it hasn't been dropped altogether from the curriculum, it has deteriorated to a fourth rate course in graphic vector analysis and mechanical drawing. It has probably done more to destroy a student's interest in machine design than any other academic activity. And we have helped it along by assigning this lowly ordeal to the least experienced instructor in the department.

It's little wonder that the major interest and activity in mechanical engineering departments has been heat power. The atrocity is magnified when we learn that over 80% of the professional membership of ASME is engaged in engineering activity associated with machine design, *not* heat power. This means that industry has had to make machine designers out of students primarily interested in heat power.

Well sir, we did something about it at N. C. State College. We have revamped this course completely. It has been up-graded to a position as one of the most important courses in the machine design sequence. It has been "jacked-up" to a serious course in engineering design analysis. Above all, it has been taught in a manner to challenge the mechanical soul of the junior engineering student.

Motives

We had some specific motives in our madness. First, we felt that teaching the professional art of applying laws of science to the creation of machines was a vital part of the student's training. It seemed logical that the sequence of machine design courses should follow the general sequence of events in a design activity: design the mechanism to accomplish the motion, then, solve for its forces, determine its stresses, size its parts, reduce its friction, and adapt it to manufacture. To wit: kinematics, dynamic analysis, and design of machine elements.

Second, if Kinematics were to be the first course in a sequence of design activity, it should develop an interest in design in the student. It should present a creative challenge to the student—a sense of accomplishment. It must "sell" machine design.

Third, every machine that moves is created as a mechanism. Kinematics should, therefore, teach how to begin to design a mechanism. The course should be devoted to creative ideation and analytical analysis of engineering motion situations. The end result would be to develop a mechanism to convert a given input motion to a desired output motion.

Fourth, and most important, this course would be the first professional course in the student's academic career. It would be responsible for cut-

ting him loose from the apron strings. It should teach him how to use his background and how to use his head! It should exercise the student toward self-reliance and self-confidence in his ability to think through an engineering motion requirement and arrive at a reasonable solution.

Purposes

These motives define the purpose of this new course. The content of the course includes methods for the design of mechanisms to convert and/or transmit motion. The field of mechanization for motion conversion and transmission is unlimited. However, a large majority of machines fall in two basic categories:

(a) Mechanisms to convert rotary motion to rotary motion. The study includes gear trains, rolling surfaces, four-bar linkages, and non-circular gears.
(b) Mechanisms to convert rotary motion to linear motion. This includes the study of the cam and slider crank mechanisms.

The course deals with problem situations involving the need for, the selection of, and the analysis of these basic mechanisms. Vector analysis and the other traditional graphical techniques (which formerly comprised the entire course emphasis) are introduced only as convenient tools to accomplish a design analysis. They are taught as one step in the process of mechanism design, no one more important than any other. Any technique is easily learned when its usefulness is clearly evident.

Methods

When dedicated to these propositions, it is inevitable that the operation of the course would have to be accomplished by the project synthesis method of teaching. Project synthesis can be defined as the synthesis of the laws and concepts of mechanics toward the solution of a realistic engineering situation. Its methods encourage the natural enthusiasm of the student and guide and counsel his activities within an environment of synthetic realism.

The technique of teaching by this method is to put the student into a realistic design situation. The instructor teaches by guidance and counsel only. The student is led to discover the art and techniques which will bring together the laws that will resolve the problem and create the mechanism. The lectures emphasize the logical paths of analysis and point up the virtues and despairs of each variable.

We emphasize that every parameter has a significant contribution to the design. We expect the student to make the decisions which will "freeze" every parameter. Every effort is made to force the student to draw his own conclusions. There is a measure of controlled frustration in this method, for we expect him to get stuck. We want the opportunity to advise a man who needs help. Often times a few pertinent questions will direct his reasoning to discover for himself exactly how he can resolve it.

Problems

The problems, simple or complex, are written in terms that describe a realistic situation. If data are specified, it is justified as a necessary and fixed requirement. A specific answer is rarely requested. Instead, we explain what is required of the design situation. This leaves the decision of what must be calculated or finally specified to the student. Consequently, his solution is a combination of parameters which will give the best over-all performance.

We accomplish this by a variety

of design problem situations. For the short introductory problems we give them a partially completed design, then ask them to make the decision for the next step. Or, we may ask them to judge whether the design thus far is correct.

Another type of problem involves a completed design. The student is asked to evaluate a proposed alteration which is supposed to improve the performance of the original design in a certain manner. Each of these problem situations is designed to emphasize one facet of design criteria. Each requires a specific analysis or computation. We are very careful not to let the wording or given information betray the solution.

Projects

When the students become more proficient, we assign them projects. These projects may be complex design situations requiring many decisions comprising many conditions or, they may be short simple designs with only a few alternatives. They are carefully planned and directed to keep the thinking and activity within the area being studied.

The problems are presented in two ways. When written, they are prepared as a situation with a request for a certain end result. These are then discussed in class before the students start to work. The discussion allows the students to ask questions to clarify their concept of the situation. It gives the instructor an opportunity to improve on the element of realism by embellishing the facts which have been presented. Here the student's enthusiasm is motivated. With some encouraging sales talk, the instructor can arouse their creative ability and soon have them attacking the problem with courageous confidence.

The oral presentation of the problem has been very successful as a valuable alternate. For this type of presentation we approach the class with a design predicament supposedly phoned to us by a company needing specialized help. We proceed to discuss the problem just as it might have been described to us. We purposely leave out vital details. The students take notes and are encouraged to ask questions until they think they have enough data to solve the problem.

If they ask for information which is to be part of the solution, we merely answer that we don't know or it wasn't given to us. If they ask for information which has nothing to do with the required solution, we oblige. The motive here is to exercise the students in the selection of information required for the problem. In fact, it actually makes them write their own problem.

The use of projects as a technique for teaching design is not new. The idea has been handled badly in the past and as a result has not met with much success. Project synthesis differs from the "old" project method in the attitude in which it is administered. The old project method was a single, complete project extending over the entire term. It failed because the instructor dragged the students through it. The student made no decisions. He plodded along doing what he was told, following the outline, piling up required calculations and answers in the specified manner.

Project synthesis purposely puts the burden of decisions and synthesis entirely on the student. This is the basic motive. It provides the experience of rational thinking which the student needs in his engineering training.

We suspect that much of the reluctance on the part of the teachers to use this method hinges directly on their attitudes toward the student.

There is a prevailing attitude that students learn by mock apprenticeship. The counsel follows the pattern: "Watch how I do it!", "Follow the sample solutions in the text!".

The Student

To teach kinematics effectively by project synthesis you must recognize some specific capabilities and needs of the student. The following items concerning the student are vital to the success of this technique:

1. The student is far enough along in his training to be weaned from the academic exercise problem. He can be put on his own to solve the realistic situation problem.

2. He needs opportunity to apply his previously studied background in mathematics and mechanics to real situations.

3. He is anxious to try himself. He has been held back (for various reasons) from engineering reality for two years. He is eager to "sink his teeth" into a design and try to develop a feasible solution.

4. A junior engineering student is "loaded" with youthful enthusiasm. It can be effectively employed as a powerful motivation in analytical and creative activity. It is rarely employed as a teaching aid. More often than not it is smothered by the traditional academic process. The objective of realistic problems is to encourage enthusiasm and self-confidence.

5. He is capable of making decisions and needs every opportunity to do so. It scares the thunder out of him when you require it for the first time, but he will surprise you when he calms down and starts to apply his head. How will he ever learn to rationalize, evaluate, and think it through if he never has to make an important design decision?

6. He must be exercised and counseled to recognize and define a problem. We should not define the class problems in explicit detail. Realistic situations present a condition—the engineer defines the problem.

This then is a new course in kinematics taught by the project synthesis method: a creative, design experience in the mechanization of motion, taught to grown men with a college background in calculus, physics, and mechanics.

APPOINTED BY NATIONAL SCIENCE FOUNDATION

Dr. Grant W. Smith has been given leave from his post as Head of the Chemistry Department at Pennsylvania State University to accept a National Science Foundation appointment as Program Director of Summer Institutes for the Division of Scientific Personnel and Education. Dr. Smith will administer the summer courses inaugurated in 1953 for high school and college teachers of science and mathematics.

The Foundation grants awards to selected colleges and universities to provide this opoprtunity for study. Last summer, 5,000 high school teachers attended 91 institutes of from six to eight weeks at colleges and universities throughout the United States.

TODAY'S OBJECTIVES IN TEACHING MACHINE DESIGN

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Presented at a conference of the Mechanical Engineering Division, June 18, 1957; recommended for publication by the Division.

There is probably no course in the engineering curriculum in which a penchant for "dusting off last year's notes" produces more chaos than in Machine Design. The trouble stems not from changes in the fundamental laws of mechanics or kinematics. These fortunately are relatively immutable. The applications of these laws, however, in a technology which evolves as rapidly as ours does, requires continual review and overhauling of course content. A periodic evaluation of machine component innovations is, of course, imperative, but even this is not sufficient to keep us up to date. Over a space of a comparatively few years, major technical and economic developments may introduce the need for a complete reconsideration of course objectives. There are a number of indications that such a reconsideration is at present in order.

Some of the more obvious trends which might be expected to exercise an influence on the content and objectives of a course in machine design are as follows:

1. Increased speed and volume of transportation.
2. Increased volume of production.
3. Extension of automatic control techniques.
4. Increased flexibility in power supply.

The list might be extended almost indefinitely. Such trends are, of course, all part of the wider picture of technological change and are hence closely interdependent. Let us briefly consider what influence each exerts in the machine design field, keeping in mind that the word "machine" in this context has come to include even the kitchen sink.

Speed and Volume of Transportation

In air, road, and rail transportation the quest for greater speed and payload continues, fostering a never-ending demand for lighter, stronger parts. Much of the job of finding materials of high strength-weight ratio falls on the metallurgist, but the designer also has his share of problems, in stability, vibration, combined stresses, theory of failure, stress concentration, and fatigue. In general, pressure to trim safely factors to the minimum requires increasingly rational methods of design: the "guestimate" is no longer good enough.

Another respect in which modern transportation imposes new demands on the designer is in the field of controls. We ordinarily have not attempted to emphasize the machine operator's physical and psychological limitations very greatly in our design instruction; this shying away from intangibles (or, put more generously, this crediting of the human operator with an unlimited resourcefulness) is rapidly becoming anachronistic. The increased reliance on mechanical or other control systems, whether for air-

craft servo-mechanisms or automobile transmissions, introduces a need to consider each machine element as a component of a larger system. Whereas before we might conveniently rely on an indefinitely intelligent human to coordinate the elements of some complex system, we now must design for an automatic controller of known limited characteristics. The general trend is fairly well exemplified in the evolution of the automobile transmission between 1937 and 1957.

A new degree of freedom, or perhaps it is more accurate to say a new degree of regimentation, has thus been introduced into the field of machine design. The change appears to be a fundamental one, sufficient perhaps to call for an entirely new approach to the teaching of design.

Increased Volume of Production

The general growth of manufacturing industries in recent years has taken place in two directions: the production of a wider variety of products, and the production of particular items in much larger quantities. The first trend presents the designer, and even more so the teacher of designers, with a formidable problem of keeping up to date on what is available. The second trend, toward larger production runs, creates a different problem. We are well aware that what constitutes a good design for turning out 100 or so items per year is more than likely to be hopelessly inadequate against a competitor's design based on a production of 100,000. The economic considerations in such cases become decisive. A good example is in the field of high grade record players, where a domestic product made almost entirely of stamped parts easily outsells and undersells its chief foreign competitor's product which is predominantly machined.

It is the writer's opinion that a serious schism has developed here between the practicing designer and the design teacher. Today's designer has had to turn out competitive designs, despite the fact that his academic training and theory have provided almost no background in some of the design techniques most essential to large quantity production: stamped, pressed, or punched parts, die-cast parts, and molded plastic parts. How the academicians can be afforded better opportunity to keep up on current industrial practice in this respect is something to think about.

One further observation may be made as to the long term effect which larger production is likely to have on design techniques. Even though there has been a lag in the development of proper theoretical methods of determining, say, the strength and stability of pressed metal parts, there is little doubt that competition will eventually require as rigorous rationality in this as in any other aspect of machine design. An extra unnecessary operation or a few mils worth of unnecessary material such as usually results from rule-of-thumb design procedures will increasingly become a disadvantage sufficient to prevent profitable marketing.

Automatic Control

The increased utilization of automatic controls in the transportation field has already been noted. An even wider utilization is taking place in office work and manufacturing. The term "automation" was, in fact, coined to identify this trend. Unfortunately, as is the case with many new and fashionable words, the meaning has become somewhat blurred by excessive usage. "Automation" has thus come to be rather loosely applied both to the current spurt in mechanization and to the new control tech-

niques which have made this greater degree of mechanization possible.

The atmosphere is already so full of intemperate predictions about the repercussions of "automation" that for me to add a few more speculations could hardly aggravate an already confused picture. Put as moderately as possible, I should say that if what we call "automation" is going to affect anything to any appreciable degree, it will certainly affect design. The influence of automation in the electronics industry, for example, are already apparent in radical design changes.

Although it seems probable that a major portion of the field of electronic controls will remain an exclusive province of the electrical engineer, it is perhaps equally probable that most of the balance of the field, including some of the simpler electronic systems and circuits, must soon become part of the stock-in-trade of the well-grounded mechanical designer. Recent developments in partially or highly automated industries indicate that both product and process are so greatly affected by the new modes of production that the designer of tomorrow will be able to function effectively only if he is equipped to consider the machine elements he deals with as components of a wider, more complicated system.

A continuation of this trend will in all probability require a major reorganization of machine design instruction. Without endeavoring to fill in the details, I should judge the need will be for mechanical engineers to receive, concurrently with their machine design course, a course in the mathematical analysis of automatic control systems. In addition, a survey of transducers should be included in the machine design course, since this is the course which has traditionally dealt with machine elements or components. This coordinated instruction in the analysis of components and systems should be followed by an applications course in which the student is exposed to an actual design experience of a system and its components. To develop staff capable of supervising such projects will, no doubt, be difficult.

Flexibility of Power Supply

One final trend which has exerted a greater influence on machine design than is often appreciated, is in the development of unitary or built-in prime movers. The familiar lineshaft of the manufacturing plant of twenty or thirty years ago has all but disappeared. The influences of the lineshaft, however, are still very much in evidence in today's machine design teaching. A considerable amount of the coverage of such topics as flat belt drives and friction clutches should logically be replaced by a consideration of the characteristics of various unitary prime movers and particularly their interaction with various types of load. More coverage of variable speed drives is also needed. In the long run, we must strive to provide the student with the intellectual tools to design not simply a machine as an aggregate of components, but to design an integrated system of machine, drive, and controls.

Conclusion

As the breadth and complexity of our technology increases, the demands on designers increase proportionately. Even though there may be a continuing need, possibly even an increasing need, for the handbook or "plug-into-formula" type of designer, an urgent need is arising for a more broadly trained and resourceful type of designer. If we are to meet this need, it appears that we must consciously pursue several definite objectives:

1. Rational design procedures must increasingly supplant rule-of-thumb techniques. For example, in the analysis of wire ropes, the application of present knowledge of combined stresses, residual stresses, Hertz bearing stresses, theory of failure and fatigue data, immediately reduces the traditional design procedures, involving safety factors of six to twelve on the ultimate load, to reasonable values of one to two.

2. Methods must be discovered for enabling teachers of design to keep more up to date on current industrial practice. New forms of industrial or sabbatical leave may provide an answer.

3. New basic theoretical material, particularly in the analysis of control components and systems, must be integrated with the machine design instruction.

4. Senior students should be afforded an opportunity to synthesize their theoretical background in a broad design experience involving a complete system of machine, drive and controls. It has often been observed that design is to a considerable extent an art, and as such can only be taught in a negative way, by criticism of the student's chosen solution to a problem.

Even if this is the case, exposure to the designer's task, preferably in a broad and challenging synthesis, can be a stimulating and illuminating experience. How well a student performs this task is a better index of what he has absorbed from his analytical courses, and of how skillfully he can bring it to bear, than any comprehensive examination. The only thing that is needed is for some especially gifted student to design us an automatic machine for grading these projects.

• • • •

What I have outlined is admittedly an ambitious program. It is nevertheless difficult to see how today's rambunctious technology will settle for less.

ENGINEERING TEACHERS DESIRING SUMMER EMPLOYMENT

The Committee for Young Engineering Teachers (CYET) of the American Society for Engineering Education, through its institutional representatives, is compiling a *new* list of engineering teachers who are interested in *summer* employment. A standard "Form Indicating Probable Availability for Summer Employment—1958" is being utilized which includes the following information: age, academic rank, degrees, field of work, type of work within field, geographical preferences, security clearances, etc.

The new list will be made available (for the cost of duplication and mailing) to industry during the early part of 1958 (no later than the first of February). Any company interested in obtaining the list should please write to: Jerry G. Richter, Program Chairman, CYET, 204 M. E. Bldg., Pennsylvania State University, University Park, Pennsylvania.

CURRENT ROTC AND PHYSICAL EDUCATION PROGRAMS IN ECPD-APPROVED ENGINEERING CURRICULA

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This paper reports a factual study of the ROTC programs included in accredited engineering curricula of American colleges and universities. It was prepared at the suggestion of Dean John H. Lampe, Chairman of the Military Affairs Committee of the Engineering College Administrative Council, and presented at the June, 1957, meeting of ASEE at Cornell University.

During the 1956 annual meeting, institutional representatives to the ECAC discussed at length the number of credits toward the engineering degree that should be allowed for ROTC work. This study was conducted in the spring of 1957 to determine current practices in ECPD accredited curricula.

Information was sought, by questionaire, from nearly all accredited engineering schools in the United States. A few curricula offered in a limited number of institutions were not included in the survey and none of the federal schools such as the U. S. Coast Guard Academy were included. A total of 142 colleges and universities were queried, with 132 responding. Data from 128 replies was usable.

The surveyed schools were divided into five groups:

(1) Land-grant colleges and universities, designated LG
(2) State universities, designated SU
(3) State-supported colleges, designated SC
(4) Municipal universities and colleges, designated MC
(5) Private universities, designated Pr.U

Questionnaire responses were distributed as follows:

	LG	SU	SC	MC	Pr.U	Total
Requested	50	14	14	7	57	142
Replied	47	14	13	6	52	132
Usable	47	14	13	5	49	128

The survey was designed to obtain certain information on requirements for the Bachelor's degree and on the number of credits carried by first-term students, as well as to shed light on the ROTC credit situation. In view of the number of variations between programs, certain simplifying procedures were used to permit comparison of the various institutions and curricula. These procedures did not affect the statistical accuracy of the results.

For purposes of analysis, all credits were converted to a semester-hour basis, except in the material which applies to first-term credits. In the tabulated data and graphs herein, curricula requiring more than eight semesters are represented by the number of credits required through the fourth year, inclusive of summer work.

TABLE I

DEGREE REQUIREMENTS
(Credits Required for B.S. Degree (or first four years) including summer work.)

ENGINEERING CURRICULUM	MAXIMUM	UPPER QUARTILE	MEDIAN	LOWER QUARTILE	MINIMUM
Aeronautical	158	150	146	140	125
Agricultural	157	152	145	141	133
Architectural	155	149	144	142	130
Ceramic	158	156	152	144	136
Chemical	161	151	146	142	127
Civil	167	152	147	142	123
Electrical	160	150	145	142	125
General	148		144		127
Geological	175	154	146	141	137
Industrial	160	149	145	139	125
Mechanical	160	149	145	142	125
Metallurgical	170	152	146	140	125
Mineral	174	155	146	142	123
Petroleum	176	154	149	140	122

Degree Requirements

Degree requirements in the various engineering curricula are described in Table I, and the number of curricula in each category from each type of institution is shown in Table Ia. It was found that the greatest number of credits required in any four-year curriculum is 176 for petroleum engineering degrees at one institution. The lowest requirement, 122 credits, occurs in petroleum engineering at another school.

TABLE Ia

CURRICULA BY TYPES OF INSTITUTIONS

ENGINEERING CURRICULUM	(47) LG	(14) SU	(13) SC	(5) MC	(47) Pr.U	(126) ALL
Aeronautical	12	8	1	1	8	30
Agricultural	26	—	—	—	—	26
Architectural	9	5	1	—	3	18
Ceramic	7	2	1	—	—	10
Chemical	29	13	4	2	29	77
Civil	46	14	11	4	41	116
Electrical	46	13	10	4	45	118
General	5	—	1	—	—	6
Geological	6	3	5	—	4	18
Industrial	17	2	3	1	12	35
Mechanical	45	13	8	4	43	113
Metallurgical	16	4	7	—	12	39
Mineral	13	3	6	—	3	25
Petroleum	5	4	5	—	4	18
TOTALS	282	84	63	16	204	649

The median for most curricula is 146. The greatest number of credits required in any ECPD curriculum is 196. This requirement was found in two of the five-year programs for which credit requirements in each curriculum are shown in Table Ib.

Ninety-five of the 128 schools surveyed have four-year programs for the Bachelor of Science degree, with 16 requiring from one to three summer terms in addition. Nine have five-year programs and of these, three require at least one summer term beyond the ten semesters. Eight other schools employ the five-year cooperative plan. Duration of degree programs is shown by number and type of institution in Table II.

Institutions were queried as to whether a five-year plan were being considered and whether; if such a program were adopted, additional time and credit might be included for ROTC work. Eight institutions indicated interest in a five-year program, but none of these were inclined

TABLE Ib

TOTAL SEMESTER CREDITS FOR FIVE YEAR PROGRAMS

ENGINEERING CURRICULUM	OHIO STATE	CORNELL	FLORIDA UNIV.	MINN. UNIV.	DARTMOUTH	RICE	VILLANOVA	WORC. POLY.
Aeronautical	188		159	166				
Agricultural	191		163	167				
Architectural	178							
Ceramic	192							
Chemical	192	196	158	173		185	185	176
Civil	196	195	160	166	172	187	180	
Electrical	189	186	154	166	172	187	184	177
General								
Geological				166				
Industrial	191		158					
Mechanical	191	196	159	166	172	188	184	
Metallurgical	193	190		162				
Mineral	190			167				
Petroleum	188							

Max. 196 Med. 177 Min. 154

TABLE II

DURATION OF B.S. DEGREE PROGRAMS

NO. OF YEARS	ADDED NO. OF CREDITS	NO. OF INSTITUTIONS					
		LG	SU	SC	MC	Pr.U	ALL
4		41	12	9	2	31	95
4	1–6	2			2	5	9
4	7–12		2	3		1	6
4	14–15			1			1
5		3				3	6
5	1–8	1				2	3
5 Coop.					1	7	8
TOTALS		47	14	13	5	49	128

to allow additional degree credit for advanced ROTC. On the other hand, five institutions which are not now contemplating a five-year program indicated that if such a program were considered, thought would be given to increasing the amount of ROTC credit allowed.

First-Term Work

Always of interest is the question of how much work is required of freshman engineering students. Table III describes the number of credits carried in the first terms of accredited engineering curricula. The maximum for any curriculum is 23, the minimum 14, and the median runs about 18. The values shown in Table III include credit allowed for physical education and R.O.T.C. The figure represents all institutions, including and excluding these subjects.

The distribution of first-term credit requirements is shown in Table IV for all engineering curricula at all insti-

TABLE III

FIRST-TERM CREDITS

ENGINEERING CURRICULUM	MAXIMUM	UPPER QUARTILE	MEDIAN	LOWER QUARTILE	MINIMUM
Aeronautical	20	19	18	17	15
Agricultural	23	19	18	17	16
Architectural	20	18	17	17	15
Ceramic	21	20	19	17	15
Chemical	21	19	18	17	15
Civil	21	18	18	17	14
Electrical	21	19	18	17	15
General	19		17½		15
Geological	20	19	18	17	15
Industrial	21	19	18	17	15
Mechanical	21	18	18	17	15
Metallurgical	22	19	18	17	15
Mineral	20	19	18	17	16
Petroleum	20	19	17	16	15

tutions. It was found that 36 curricula require a maximum of fifteen credits, while in one program, the requirement is as high as twenty-three credits. The 18 credits found to be the median requirement occur in 204 curricula.

TABLE IV

INSTITUTIONAL DISTRIBUTION OF FIRST-TERM CREDITS

CREDITS	NUMBER OF CURRICULA AT					ALL INST.
	47 LG	14 SU	13 SC	5 MC	49 Pr.U	
14			1			1
15	11	17			8	36
16	18	14	1	2	22	57
17	74	22	20	1	54	171
18	92	27	17	13	55	204
19	57	4	18		42	121
20	20		6		20	46
21	8					8
22	1					1
23	1					1
Maximum	23	19	20	18	20	23
Median	18	17	18	18	18	18
Minimum	15	15	14	16	15	14
Mode	18	18	17	18	18	18

Physical Education

Since there is some relation between physical education and ROTC programs, physical education requirements in the surveyed institutions were studied. Table V shows the number of semesters, the clock hours per week, and the engineering degree credits granted for physical education courses at the 128 institutions.

It was found that the maximum requirement, eight semesters, occurs at three institutions, while 21 institutions require none. The largest number, 58, require four semesters. The maximum hours per week is six, at two institutions; 43 schools require two hours per week, while 45 schools require three. Sixty-one institutions allowed no credit toward the engineering degree for physical education. However, 29 schools allow four credits, and 25 institutions allow two credits.

As also shown in Table V, some institutions allow substitution of ROTC credits for physical education requirements. The maximum allowance is nine credits, though 99 schools allow no substitution.

TABLE V

PHYSICAL EDUCATION PROGRAMS

	NUMBER OF INSTITUTIONS				
	LG	SU	SC & MC (combined)	Pr.U	ALL
REQUIRED SEMESTERS					
0	8	4	2	7	21
1	1		2	1	4
2	13	4	7	14	38
3				3	3
4	24	6	7	21	58
6				1	1
8	1			2	3
Maximum	8	4	4	8	8
Median	4	2	2	4	3
Minimum	0	0	0	0	0
CLOCK HRS/WEEK					
0	9	5	2	7	23
1	1	1	3	2	7
2	17	3	9	14	43
3	18	4	3	20	45
4	2	1	1	4	8
6				2	2
DEGREE CREDIT					
0	20	6	6	29	61
1	2		1	2	5
2	12	4	5	4	25
3	1		1	2	4
4	12	4	5	8	29
8				3	3
9				1	1
Maximum	4	4	4	9	9
Median	2	2	2	0	1
Minimum	0	0	0	0	0
ROTC SUBSTITUTE CREDITS					
0	44	7	11	35	99
2	1	4	1	4	10
3				1	1
4	2	3	4	6	15
8				2	2
9				1	1
Maximum	4	4	4	9	9
Minimum	0	0	0	0	0

Basic ROTC

The basic ROTC programs, or those given in the first two years of the engineering curricula, are described in Table VI, which shows the distribution, among the 128 institutions, of the various types of ROTC. As can be seen, 123 institutions offer an ROTC program of some kind. Seventy-one of these require participation in the

TABLE VI

DISTRIBUTION OF ROTC PROGRAMS

TYPE OF PROGRAM	NUMBER OF INSTITUTIONS PARTICIPATING					
	LG	SU	SC	MC	Pr.U	TOTAL
AF ROTC	44	14	7	3	28	96
Army ROTC	45	12	10	4	28	99
Branch General	(35)	(9)	(3)	(3)	(16)	(66)
Specialized Branch	(10)	(3)	(7)	(1)	(12)	(33)
N ROTC	15	11			17	43
Any ROTC	47	14	12	5	45	123
Required ROTC	45	7	6	1	12	71
Elective ROTC	2	7	6	4	33	52

program, while 52 offer ROTC as an elective. Air Force ROTC is offered at 96 institutions, Army ROTC at 99, and Naval ROTC at 43. Army ROTC may be a "branch general" program or a "specialized branch" program.

Tables VIa and VIb give additional information on the basic ROTC programs for all engineering institutions and all curricula surveyed. The course semester credits shown for the institutions participating in AF ROTC and ROTC (Army) programs represent the number of credits granted by the institution for successful completion of the basic program. The engineering degree credits shown indicate the amount of credit toward the engineering degree that is allowed for completion of the basic program. It can be seen, in Table VIa, that 14 institutions grant no course credit for the AF and Army programs, and 18 schools allow no degree credit. The medians for the group, however, are six course credits and four degree credits.

The Naval ROTC program for the

TABLE VIA

BASIC AF ROTC AND ROTC

AF & ARMY ROTC CREDITS	NO. OF INSTITUTIONS GRANTING ENGINEERING DEGREE CREDIT						NO. OF INSTITUTIONS GRANTING COURSE CREDIT					
	LG	SU	SC	MC	Pr.U	TOTAL	LG	SU	SC	MC	Pr.U	TOTAL
0	3	3	1	1	12	16	2		2		10	14
2		1			3	4						
3					1	1						
4	22	3	5	2	8	40	23	3	4	2	11	43
5	1				1	2	1				1	2
6	5	3	1	2	3	14	5	1	1	2	4	13
7	1		1		2	4	1				2	3
8	13	4	4		11	32	13	10	6	1	14	44
9	1					1	1				1	1
11					1	1					1	1
12	1				3	4	1				4	5
Maximum	12	8	8	6	12	12	12	8	8	8	12	12
Median	4	5	5	4	4	4	4	8	6	6	6	6
Minimum	0	0	0	0	0	0	0	4	0	4	0	0

TABLE VIb

Basic Naval ROTC

NROTC CREDIT	COURSE CREDIT			DEGREE CREDIT ALL INSTITUTIONS
	LG	SU	Pr.U	
0	2	3	5	10
2		1		1
4	5	1	1	7
6	3	1	2	6
8		1		1
9		1	1	2
10	1			1
12	4	2	8	15
Maximum	12	12	12	12
Median	6	6	9	6
Minimum	0	0	0	0

first two years consists of four semesters of three credits each. Of the thirty-seven institutions participating in NROTC 10 allow no credit toward the engineering degree, while the median number of degree credits granted is six. Distribution of basic Naval ROTC credit is shown in Table VIb.

Advanced ROTC

Course credit and engineering degree credit for advanced, or third- and fourth-year AF and Army ROTC are shown in Table VII. Here, eight of the institutions participating allow no course credit, and 26 of them allow no engineering degree credit for advanced ROTC work. The medians are 12 course credits and 9 engineering degree credits.

The 43 institutions participating in advanced NROTC include seven which allow no engineering degree credit, but exhibit a median of 12 degree credits. The distribution of ad-

TABLE VII

Course and Degree Credit for Advanced AF and Army ROTC Programs

CREDITS	ENGINEERING DEGREE CREDIT BY TYPE OF INSTITUTION						COURSE CREDIT BY TYPE OF INSTITUTION					
	LG	SU	SC	MC	Pr.U	TOTALS	LG	SU	SC	MC	Pr.U	TOTALS
0	7	3	4	3	9	26			1		7	8
1						0						0
2						0						0
3	2		1	1	1	5						0
4	1	1			2	4						0
5	1				2	3	1					1
6	8	2	2		2	14	2		2		1	5
7	1				1	2					1	1
8	3	1	1		3	8	2		1	1	4	8
9	2	1			1	4						0
10				1		1				1		1
11					1	1					1	1
12	21	5	4		18	48	38	8	8	3	24	81
13						0						0
14	1				1	2	2				1	3
15						0						0
16		1			2	3	2	6			4	12
TOTALS	47	14	12	5	43	121	47	14	12	5	43	121
Maximum	14	16	12	10	16	16	16	16	12	12	16	16
Median	9	8.5	6	0	12	9	12	12	12	12	12	12
Minimum	0	0	0	0	0	0	5	12	0	8	0	0

TABLE VIII

ENGINEERING DEGREE CREDIT FOR ADVANCED NROTC

NROTC CREDIT	COURSE			DEGREE CREDIT ALL INSTITUTIONS
	LG	SU	Pr.U	
0		3	4	7
3	2		1	3
4		1		1
5			1	1
6	1	2	1	4
9	1	1	1	3
10			1	1
12	11	4	7	22
Maximum	12	12	12	12
Median	12	6	8	12
Minimum	3	0	3	0

vanced NROTC credit is shown in Table VIII.

A number of institutions allow substitution of advanced ROTC credits for technical, humanistic and social, or elective courses. Where no provision for substitution is made, it is assumed that the student carries advanced ROTC work by means of an overload. Substitution of advanced AF or Army ROTC for technical courses varies from one to eleven credits, that for humanistic and social courses varies from two to 16 credits, and that for electives varies from three to sixteen credits. Provisions for AF and Army substitution are given in detail in Table IX.

The institutions participating in Naval ROTC programs allow substitution of from two to twelve credits for technical and for humanistic and social courses, and three to twelve credits for elective courses. Provisions for substitution and overload of advanced NROTC are shown in Table X.

Significant Attitudes and Comments

All institutions in this survey were asked to express the degree to which they are satisfied with the present ROTC and Physical Education programs by indicating "Well," "Medium," or "Poor." Responses are shown in Table XI. Forty-four per cent of the surveyed schools were well satisfied with AF ROTC programs, 40 per cent expressed medium satisfaction, and 16 per cent thought the program poor. In the same order, degree of satisfaction with Army ROTC was 45 per cent, 39 per cent, and 16 per cent. Percentages for NROTC were 34, 32, and 34. As to physical education programs, 71 per cent of the institutions were well satisfied, 21 per cent were medium, and eight per cent thought their programs were poor.

Institutions were also queried as to their satisfaction with the total credits required for the engineering degree, but responses were insufficient for tabulation.

Respondents made a number of significant comments which are summarized in Table XII. Nearly one-third of the institutions surveyed recommended (1) that advanced ROTC be carried only as overload, (2) that no advanced ROTC credit be granted toward the engineering degree, or (3) that degree credit for ROTC work be reduced. Other suggestions included optional ROTC, summer-camp ROTC only, and the substitution of academic work for required ROTC credits. One institution recommended that additional ROTC be allowed as a substitute for academic work in the humanistic and social studies. Another stated that the three types of ROTC should be more alike,

TABLE IX

PROVISIONS FOR SUBSTITUTION OF ADVANCED AF AND ARMY ROTC

	SUBSTITUTION CREDITS	NUMBER OF INSTITUTIONS					
		LG	SU	SC	MC	Pr.U	ALL
Technical Courses	0	38	11	10	4	29	92
	1				0		1
	2			0		2	3
	3	2	1	1	1	3	7
	4	2				1	3
	5	1					1
	6	3	1	1		6	11
	8	1				1	2
	9					1	1
	11		1				1
Humanistic and Social Courses	0	34	8	10	4	27	83
	2		1				1
	3	2	1	1		1	5
	4	1					1
	5					1	1
	6	3		1		10	14
	8					1	1
	9		2		1	1	4
	10	2					2
	12	5	1			2	8
	16		1				1
Elective Courses	0	11	4	4	3	22	44
	3	3		1	1	2	7
	4	3				1	4
	5	1				1	2
	6	12	3	3	1	6	25
	7			1		1	2
	8	2		1		2	5
	9	1	1			2	4
	10	1	1				2
	11		1				1
	12	12	3	2		4	21
	14	1				1	2
	16		1			1	2
Overload	0	20	4	6	1	26	57
	1	1					1
	2					1	1
	3	1				3	4
	4	2	1			1	4
	5		1			1	2
	6	9	3	2		2	16
	7	2	1			2	5
	8	2			1	1	4
	9	3		1	1		5
	10	1				1	2
	12	6	3	3	2	4	18
	13		1				1
	16		1				1

TABLE X

PROVISIONS FOR SUBSTITUTION OF ADVANCED NROTC

	SUBSTITUTION CREDITS	NUMBER OF INSTITUTIONS			
		LG	SU	Pr.U	ALL
Technical Courses	0	13	8	10	31
	2			2	2
	3		1	1	2
	4	1			1
	6	1	1	3	5
	8			1	1
	12		1		1
Humanistic and Social Courses	0	9	5	8	22
	2		1		1
	3	1	1		3
	6	1		3	4
	8			1	1
	9		1	1	2
	10	1	1		2
	11				
	12	2	2	3	7
Elective Courses	0	1	4	9	14
	3	3			3
	4			1	1
	6	2	2	2	6
	8	1			1
	9		1	1	2
	10	1	1		2
	11		1		1
	12	7	2	3	12
Overload	0	8	3	14	25
	1		1		1
	3	1	2		3
	4	1			1
	6	2	1	2	5
	8	1			1
	9	2		1	3
	12		4		4

and one statement was made to the effect that ROTC provided leadership training.

Eighteen institutions recommended a reduction of the number of degree credits allowed for physical education, while two recommended that physical education credits be increased. Fifteen institutions recommended a reduction of the total credit requirement for the engineering degree, whereas four recommended that the requirement be increased.

Conclusion

Responses to this survey indicated a wide variance among institutions and among curricula within given institutions, both as to degree requirements and as to ROTC credit allowances. Figure 1 (see bar graphs on pages 302 and 303) provides a visual

TABLE XI

DEGREE OF SATISFACTION WITH ROTC AND PHYSICAL EDUCATION PROGRAMS

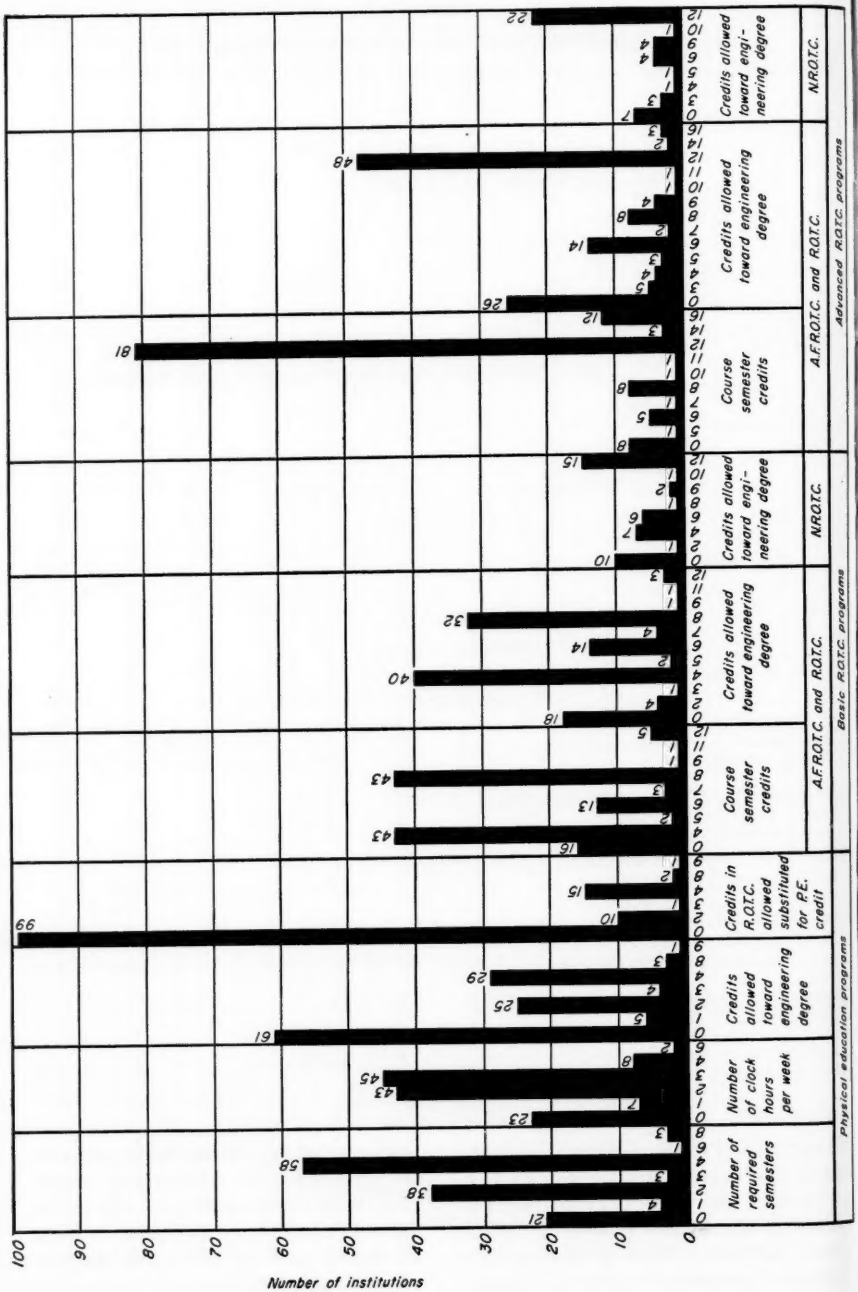
		LG	SU	SC	MC	Pr.U	TOTAL	%
A.F.R.O.T.C.	No.	43	14	7	3	26	93	
	Well	18	6	6	3	8	41	44
	Med.	19	5	1		12	37	40
	Poor	6	3			6	15	16
R.O.T.C.	No.	46	13	10	4	26	99	
	Well	20	6	7	3	8	44	45
	Med.	20	4	3	1	11	39	39
	Poor	6	3			7	16	16
N.R.O.T.C.	No.	15	11			15	41	
	Well	7	4			3	14	34
	Med.	4	5			4	13	32
	Poor	4	2			8	14	34
Phys. Ed.	No.	43	14	13	5	43	118	
	Well	25	12	11	3	33	84	71
	Med.	12	1	2	2	8	25	21
	Poor	6	1			2	9	8

TABLE XII

SUMMARY OF COMMENTS

	LG	SU	SC	MC	Pr.U	TOTAL
Total number	47	14	13	5	49	128
Number commenting	33	8	5	3	37	86
No advanced ROTC cr. toward engr. degr.	5	1			4	10
Reduce ROTC credit toward engr. degr.	10	4			10	24
Advanced ROTC as overload	2	1			3	6
Engr. with option in ROTC			1		1	2
ROTC total in Summer Camp		1			1	2
Sub. academic courses for ROTC			1			1
Incr. ROTC sub. for H & S				1		1
Air, Army, Navy ROTC to be more alike					1	1
ROTC provides leadership training			1			1
Reduce P.E. cr. toward engr. degree	10	1	1	1	5	18
Increase P.E.				1	1	2
Reduce total cr. for degree	6	1	1		7	15
Increase total cr. for degree					4	4

impression of the variations. It would seem that current practices in ECPD-approved curricula provide precedence for almost any type of program. One institution even indicated that certain humanistic or social courses are now being substituted for courses in Army ROTC. Almost any conditions which engineering schools might wish to obtain can be found to exist in one or more of the approved curricula studied herein.


Number of institutions
100
90
80
70
60
50
40
30
20
10
0
Physical education programs
Basic R.O.T.C. programs
Advanced R.O.T.C. programs
Number of required semesters
Number of clock hours per week
Credits allowed toward engineering degree
Credits in R.O.T.C. allowed substituted for P.E. credit
Course semester credits
A.F.R.O.T.C. and R.O.T.C.
Credits allowed toward engineering degree
Credits allowed toward engineering degree
NR.O.T.C.
Course semester credits
A.F.R.O.T.C. and R.O.T.C.
Credits allowed toward engineering degree
Credits allowed toward engineering degree
NR.O.T.C.

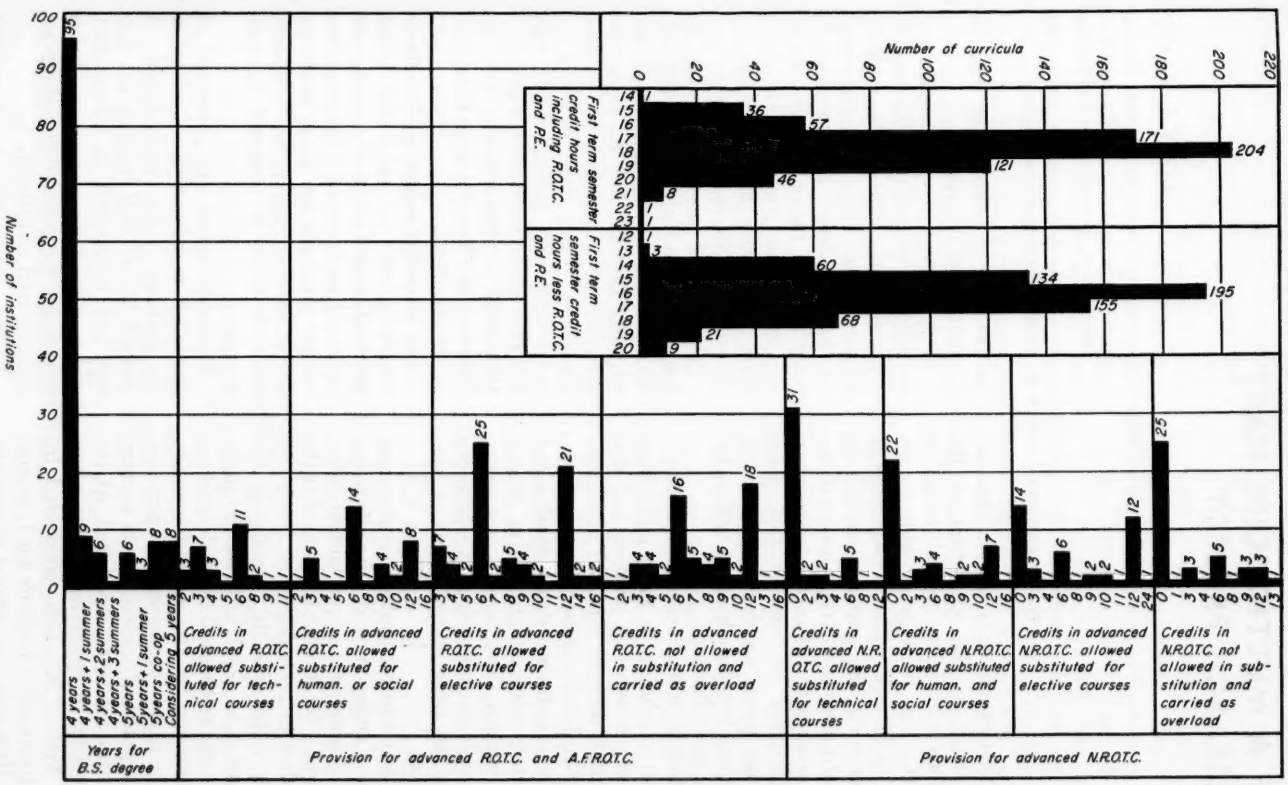

Number of institutions
Number of curricula
First term semester credit hours including R.O.T.C. and P.E.
First term semester credit hours less R.O.T.C. and P.E.
4 years
4 years + 1 summer
4 years + 2 summers
4 years + 3 summers
5 years
5 years + 1 summer
5 years co-op
Considering 5 years
Credits in advanced R.O.T.C. allowed substituted for technical courses
Credits in advanced R.O.T.C. allowed substituted for human. or social courses
Credits in advanced R.O.T.C. allowed substituted for elective courses
Credits in advanced R.O.T.C. not allowed in substitution and carried as overload
Credits in advanced N.R.O.T.C. allowed substituted for technical courses
Credits in advanced N.R.O.T.C. allowed substituted for human. and social courses
Credits in advanced N.R.O.T.C. allowed substituted for elective courses
Credits in N.R.O.T.C. not allowed in substitution and carried as overload
Years for B.S. degree
Provision for advanced R.O.T.C. and A.F.R.O.T.C.
Provision for advanced N.R.O.T.C.

FIG. 1. *ROTC and Physical Education programs in ECPD-approved engineering curricula.*

Physical education programs				Basic R.O.T.C. programs			Advanced R.O.T.C. programs		
required semesters	hours per week	toward engineering degree	allowed substituted for P.E. credit	A.F.R.O.T.C. and R.O.T.C. credits	A.F.R.O.T.C. and R.O.T.C. degree	N.R.O.T.C. engineering degree	A.F.R.O.T.C. and R.O.T.C. credits	A.F.R.O.T.C. and R.O.T.C. degree	N.R.O.T.C. engineering degree

THE ADVANTAGES AND OPERATION OF A MULTIDISCIPLINARY RESEARCH PROJECT

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Project Big Ben was successfully completed in October, 1958. This article was prepared during the active operation of the project.

Cooperation in research becomes necessary as the expansion of the various fields forces specialists farther apart. Far from being able to acquaint himself with developments in other areas, the conscientious scholar is hard-pressed to keep abreast of developments in his own. Information accumulates so rapidly that mere storage poses problems, and the individual becomes isolated within his own specialization.

Multidisciplinary cooperation, which offers a solution to these difficulties, is not extensive at present, and this failing is strongly reflected in our colleges and universities. It seems especially unfortunate that extensive and effective working association among the various disciplines is not maintained in these institutions where one finds the richest assortments of specialists.

Theoretically, academic researchers seek a common goal: the discovery and communication of factual information. Yet it often happens that the scholars in each discipline think and work independently, remaining oblivious of, if not hostile to, the problems and methods of other disciplines.

However, as the need for multidisciplinary cooperation increases, some practical means for its encouragement are being developed. At the University of Pennsylvania, for example, Project Big Ben, conducted by the University's Institute for Cooperative Research, has gained experience in this type of research for a period of more than five years.

Here, a great many specialists representing a variety of skills and disciplines work together in multidisciplinary research toward an over-all, or "total," solution that involves the integration of many sub-parts. In order to illustrate some aspects of this type of research, Project Big Ben is described below in some detail.

The project was named for the founder of the University, Ben Franklin, whose bid for a measure of universality brought him an impressive diversity of knowledge and accomplishment. "Big Ben" employs approximately sixty specialists who work together on a contract between the University of Pennsylvania and the Research and Development Command of the Air Force.

The project is organized into six research groups in which the social, physical, and biological sciences are variously represented. Three or four related problems are under investigation within each group, and a separate research team is assigned to each problem.

Research teams are composed of specialists in all disciplines related to the problem under investigation. A general library staff handles the storage and transmittal of information, and a general communication staff is responsible for presenting findings accurately and effectively.

Within "Big Ben" a supervisory

body periodically defines the various research tasks that must be undertaken to advance the over-all research effort of the project. This body, which is composed of the director, his deputy, and the chairmen of the six groups, then selects the specialists who are assigned to each particular task. One of these specialists is appointed supervisor of the team effort. Intervals for reporting progress are agreed upon, and the research team is ready to operate.

Let us assume that the project has undertaken an investigation of the effects that destruction of a major portion of an industrial area would have upon the social and economic complexes of the nation. The team selected to undertake this work would probably be composed of economists, statisticians, psychologists, sociologists, political scientists, experts in communications, and geographers specializing in industry, transportation, and cartography.

A subject index of research abstracts, maintained by the editorial staff, would provide the team with a ready reference to related research previously or currently undertaken within the project. The library staff would assist in the preparation of bibliographies and indices of pertinent external work. Through regularly prepared activity reports and informal discussion in staff conferences, the team would inform other members of Project Big Ben of their progress.

In the initial conferences of the team, assignments would be made to the appropriate specialists; methods for abstracting, coding, and, if necessary, mechanical handling of the available data would be agreed upon; and systems for the development of new data would be determined. Next, the team would devise a general operating procedure and select means for the final synthesis of its work.

During regular, informal conferences, the team would discuss the techniques currently being employed by the various specialists. These discussions would ensure that each individual received the benefit of the diverse experience of the team, and would provide for uniformity in the presentation of individual results. By these and similar cooperative measures, the information necessary for a coherent final report would be produced.

Upon completion of its research tasks, the team would be assisted by the editorial and graphics staffs in preparing a final report of the findings. This report would be reviewed by specialists in the fields with which it was most directly concerned, as well as by a number of specialists in other fields. Through this type of cooperation, both the accuracy and the intelligibility of the report would be rigorously tested.

The final version of the report would be submitted to interested government agencies. If security permitted, the findings would also be published in the open literature.

The cooperative effort of the research team outlined above is similar to that followed by the directorate and the chairmen of the six research groups in coordinating the work of the teams. At all levels within the Project, cooperation is the basic feature of operating procedures. The characteristic element of the operation is the open, informal conference, rather than the official directive; its characteristic product is the joint report on a subject of wide scope rather than the jealously guarded monograph.

As the work of Project Big Ben and other multidisciplinary projects advances, various techniques for the maintenance of effective cooperation

among the various specialists are being developed. Many difficulties, of course, arise out of differences in methodology and terminology, but experience suggests that frequent, informal discussion periods can go far toward dissolving these difficulties.

Freedom of individual initiative is, of course, of primary importance in all research. It should be emphasized that the purpose of multidisciplinary organization and supervision of research, as exemplified by the "Big Ben" operation, is by no means to stifle, but rather to encourage, initiative and originality, and to provide a fertile soil and favorable climate wherein these qualities may flourish.

Individuality is actually the *raison d'etre* of multidisciplinary research. Enlightened management of such research strives for full utilization of individual thought and ability by making easily available to specialists in any one field the concepts, information, and techniques developed by specialists in other fields. Working alone, a social scientist may abandon a problem that his own mathematics are not sufficient to handle. But if he has immediate access to a specialist in applied mathematics, an engineer, or perhaps a physicist or chemist, a method for solving the problem may well be devised.

Many current problems in economics, for example, involve both linear equations and inequalities. Although the mathematical theory of such systems has been thoroughly developed, this branch of mathematical analysis is not part of the normal equipment of the theoretical economist.*

Thus it is within the power of research supervision to advance the work of the individual researcher by freeing him from the time and labor of making his own investigation into areas with which he is not thoroughly familiar. When the means are provided for free association among specialists, it is often possible for the individual researcher to employ data and systems that he might not have been able to discover or apply independently.

Art, as Faust realized, is long, and life is fleeting. Art is also increasingly complex, and the isolated efforts of individual scholars grow less and less effectual in seeking out its mysteries. But perhaps, if the universities turn their attention to the insufficiently coordinated research program, something of the age-old ideal of universality may be brought once again within the grasp of the learned community.

* David Gale, "Mathematics and Economic Models," *American Scientist*, Volume 44, No. 1, January 1956.

SMITH TO DIRECT RESEARCH

J. F. Downie Smith, former Dean of the Division of Engineering at Iowa State College, joined the Carrier Corporation on January 1 as Vice President and Director of Research and Development. Dean Smith has been a member of ASEE since 1947. He is RWI representative to the Council and served as Chairman of the Secondary Schools Committee of ECAC for 1956–57.

FACULTY EMPLOYMENT PROGRAMS, SUMMER, 1958

Compiled by
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Michigan College of Mining and Technology, Houghton

The bonds which link the faculties of our colleges training engineers for industrial careers and the industries they serve are many and strong. One important sinew among these bonds is the first-hand intimacy developed during periods when professors work in industry. Last year (JOURNAL, March, 1957) an initial effort was made to summarize such opportunities available to professors for summer work in industries which were already contributing to engineering education through memberships in the ASEE.*

There is evidence that the first compilation published was successful in each of its three purposes, namely: 1) to provide professors a list of opportunities open to them, together with an indication of the kind of activity offered by each company, 2) to provide companies publicity for their programs and 3) to provide companies not already offering summer employment a guide to what others have found possible and desirable.

It was particularly encouraging to discover that several organizations which had never employed college faculty members during the summer were stimulated by the publication of last year's compilation to make plans for such programs in 1958. The 1958 directory is therefore considerably larger and more nearly complete than that of last year. Increases in the number of participants expected and the expansion of special activities for professors indicate real progress.

This directory contains two sections: Part I includes the programs in which special activities are planned to provide professors with as broad a picture of the company's operations as possible. In Part II are listed organizations which offer summer work on a less formal basis.

Certain other related activities not mentioned here are carried out in several companies. These include tours, open houses, faculty visits, and conferences on a one- or two-day basis. It has not been possible to summarize all of this kind of programs in the present survey.

Many organizations will be modifying their plans somewhat as summer approaches. Unfortunately, the printer's deadline required that they predict nine months in advance what their 1958 plans would be for early publication. Additional opportunities will undoubtedly develop by summer in some companies not now listed. In each case, too, the exact number of participants depends on how well the qualifications of applicants match the assignments available. It is hoped that, if the directory proves its continued usefulness, it will be revised again for publication in 1959.

* The Committee for Young Engineering Teachers is also repeating a "Summer Employment Contact Service," first offered last year, to make available to industrial groups who request it a list of faculty members interested in seeking summer employment. The list, to be available in February, is expected to include several hundred names and also provide pertinent information concerning the location and qualifications of each. Companies looking for help in a specific field should contact Professor J. G. Richter, Department of Mechanical Engineering, Pennsylvania State University, University Park, Pennsylvania.

PART I. FORMAL PROGRAMS

Key to Symbols Used in Compilation, Columns 5–8

5. Other activities
   - U tours of facilities
   - V social and recreation
   - W luncheons etc. with company personnel

6. Basis for payment
   - S college salary rate
   - Q job assignment and qualifications
   - R honorarium or fixed stipend
   - N no payment (except allowances, Col. 7)

7. Other allowances
   - T travel
   - F food
   - H housing
   - C cost of living

8. Individual assignment
   - J job on company project
   - K study some phase of company's operation
   - L none

Company (Name and Address)	Contact (Person and Position)	Background Included 1	Length, Weeks 2	Number of Participants 3	Number of Seminars 4	Other Activities 5	Basis for Payment 6	Other Allowances 7	Individual Assignment 8
Allison Division General Motors Corp. Indianapolis 6, Ind.	R. C. Smith General Supervisor Salaried Personnel Dept.	Tech.	8–12	6–25	4	W	S	T	J
Boeing Airplane Co. Seattle, Wash. (Wichita, Kansas) (Melbourne, Fla)	John C. Sanders Eng'g Pers. Administrator	Tech.	8–12	50–60	15	U, V, W	S	T	J
California Research Corp. 200 Bush Street San Francisco 4 California	D. P. Krotz Asst. to the President	Tech.	8–12	2–5	—	U	Q	T	J
Chance Vought Aircraft Dallas, Texas	R. S. Stiff College Relations Representative	Tech.	8+	36	10	U, V	Q	T, H	J
Continental Oil Co. P. O. Box 2197 Houston 1, Texas	Richard R. Crow Asst. Manager Industrial Relations Dept.	Non-Tech.	1–8	5–10 *	—	—	Q or R	T, F, H	J or K
Convair, Division of General Dynamics Corp. Fort Worth, Texas	H. A. Bodly Administrative Supervisor Engineering Personnel	Tech.	8–12	15–20	2–5	U, V	Q	T	J
Detroit Edison Co. 200 Second Avenue Detroit 26, Mich.	A. R. Hellwarth Asst. to Director of Employment	Tech. Non-Tech.	8–12	5–10	2	U, V, W	Q	T	J
Douglas Aircraft Co. Santa Monica, Calif.	C. C. La Vene Employment Manager Engineering Division	Tech.	10+	20–25	—	U	Q	T	J
E. I. DuPont de Nemours & Co. Wilmington 98, Del.	P. B. Lewis, Manager Personnel Division Employee Relations Dept.	Tech.	8–12	20–30	—	U, V, W	Q	T	J
Esso Research and Engineering P. O. Box 175 Linden, New Jersey	C. W. Smith Employee Relations	Tech.	12	2–5	—	U	Q	T	J
Ethyl Corporation 1600 W. Eight Mile Road Ferndale 20 Detroit, Mich.	Harold Soroos Administration and Services Research Laboratories	Tech.	8–12	2–5	8	U, V	Q	T	J
General Electric Company Schenectady, N. Y. (and others)	W. Scott Hill Manager, Recruiting Eng'g Personnel Department	Tech.	8–12	25–30	20	U, V, W	S	T, C	J
General Motors Corporation Detroit 2, Mich.	Kenneth A. Meade Dir. Ed. Relations	Tech.	2	20–30	9	U, V, W	N	T, F, H	K

* Only applicants from the area near the company's operations are considered for summer employment.

PART. I.—*Continued*

Company (Name and Address)	Contact (Person and Position)	Background Included 1	Length, Weeks 2	Number of Participants 3	Number of Seminars 4	Other Activities 5	Basis for Payment 6	Other Allowances 7	Individual Assignment 8
Humble Oil and Refining Company Houston 1, Texas	R. N. Dyer, Head Personnel Division Employee Relations Dept.	Tech. Non-Tech.	8–12	40–50	8	—	Q	T, H	J
International Business Machines Corp. 590 Madison Avenue New York 22, New York	R. A. Whitehorne Manager, Technical Recruitment	Tech.	8–10	30–40	7	U, V, W	S	T	J
Lockheed Aircraft Corporation California Div. Burbank, California	E. W. Des Laurlers Employment Manager	Tech.	8–12	5	5	U, W	S	T	J
McDonnell Aircraft Municipal Airport St. Louis 3, Mo.	C. J. O'Toole Asst. Employment Manager	Tech.	10+	15–25	—	U, W	Q	T	J
Minneapolis-Honeywell Regulator Company Minneapolis 8, Minn.	A. Lachlan Reed Director, Industry-Education Relations	Tech.	8–14	10–20	5 to 10	U, W	S	T	J
Minnesota Mining & Manufacturing Co. Saint Paul 6, Minn.	Wendel W. Burton Employment Manager 900 Fauquier Ave.	Tech.	8–10	5–6	1	U, V, W	S	T	J
Pratt & Whitney Aircraft East Hartford, Conn.	Roycroft Walsh, Jr. Engineering Department	Tech.	8–12	20–30	6	U, V, W	S	T	J
Public Service Electric and Gas Co. 80 Park Place Newark 1, New Jersey	Herbert Wottrich Assistant to General Manager Electrical Department	Tech.	8–12	5	4	U, W	Q	—	J
Sandia Corporation Sandia Base Albuquerque, N. M.	K. A. Smith, Manager Employment and Personnel Dept.	Tech	12	25–35	—	U, V	Q	T	J
Standard Oil Co. (Ind.) Research Dept. Box 421 Whiting, Ind.	J. G. Hunter Administrative Director Whiting Laboratories	Tech.	8–12	5–6	3	U, V, W	Q	T	J
Stromberg-Carlson Co. Div. of General Dynamics Corp. Rochester 3, N. Y.	Arthur N. Paul Director of Technical Personnel	Tech.	8+	5–10	—	U, V, W	S	T	J
Sun Oil Company Research & Dev. Dept. Marcus Hook, Pa.	J. Harold Perrine Manager Administrative Div.	Tech.	8–12	2–5	4 to 6	U, V	Q	—	J
Thomas A. Edison Industries 51 Lakeside Ave. West Orange, N. J.	Donald W. Collier Vice President & Director of Reseach	Tech.	8–12	1	O	U, W	S	—	J
Union Carbide Corp. 30 E. 42nd Street New York 17, N. Y. (Various Divisions)	Vernon O. Davis Coordinator of College Recruiting	Tech.	8–12	50	10	U, V, W	S, Q	T	J
U. S. Steel Corp. 525 William Penn Place Pittsburgh 30, Pa.	C. D. Feight, Director Employment and Placement	Tech.	9	10–20	9	U, V, W	S	T	J
Western Electric Co. 195 Broadway New York 7, New York	R. W. Reckhow Coordinator of College Relations	Tech.	8–12	15–25	3	U, W	Q	—	J
Westinghouse Electric Company East Pittsburgh, Pa.	R. Craig Fabian, Supv. University Relations Education Dept.	Tech.	12–14	20–25	1	U, V, W	R	T, F, H	J

PART II. INFORMAL EMPLOYMENT

Company	Contact
Acme Steel Company Chicago 27, Illinois	H. L. Bills, Vice-President and Director of Industrial Relations
Air Reduction Company 150 E. 42nd St., New York 17	F. R. Balcar, Coordinator Research and Engineering
Allis Chalmers Manufacturing Co. Box 512, Milwaukee 1, Wisconsin	Paul A. Bierwagen, Supv., Graduate Studies, Graduate Training Section
Aluminum Company of America Pittsburgh 19, Pennsylvania	R. L. Gaughler Manager of College Relations
American Cyanamid Co. 30 Rockefeller Plaza New York 20, New York	Frank H. Hurley, Manager College Relations
American Viscose Corp. Marcus Hook, Pennsylvania	A. Ross Adams Asst. to Vice President
Arthur D. Little, Inc. 30 Memorial Drive Cambridge 42, Mass.	James M. Jager Personnel Director
Bethlehem Steel Co. Bethlehem, Pennsylvania	A. M. Rupkey Manager of Personnel
Canadair, Limited P. O. Box 6087, Montreal, P.Q., Canada	L. Wiebe Engineering Services Supervisor
Caterpillar Tractor Company Peoria, Illinois	N. M. Nelson Employee Relations Manager
Chemstrand Corporation Decatur, Alabama	A. D. Preston Technical Personnel Manager
Chrysler Institute of Engrg. Detroit 31, Michigan	L. R. Baker, Director
The Cleveland Electric Illuminating Co. 75 Public Square Cleveland 1, Ohio	J. P. Fleming, General Supervisor Personnel Services Section
Continental Motors Corp. 8647 Lyndon Street Detroit 38, Michigan	Peter Altman Vice President
Corning Glass Works Corning, New York	L. W. Larson Director of Training
Eastman Kodak Company 343 State Street Rochester 4, New York	J. H. Howard, Director Business and Technical Personnel
Erie Resistor Corp. Erie 6, Pennsylvania	Robert W. Sparks, Supervisor of Placement and Training
Food Machinery & Chemical Corp. 161 E. 42nd St., New York 17, N. Y.	J. S. Thomas Technical Personnel Manager
Ford Motor Company 21500 Oakwood Boulevard P. O. Box 2053, Dearborn, Mich.	Francis J. Budde, Section Supv. Salaried Personnel, Training and Employee Services Department

Company	Contact
General Electric Company Schenectady, New York (and others)	W. Scott Hill Manager, Recruiting Engrg. Personnel Dept.
Goodyear Tire & Rubber Co. Akron 16, Ohio	R. N. Whitcomb, College Relations Technical Personnel
Hughes Aircraft Company Culver City, California	F. A. Scott, Office of Advanced Studies Research & Development Laboratories
International Harvester Co. 180 North Michigan Avenue Chicago, Illinois	F. D. MacDonald, Chairman Manpower Committee Education & Personnel Department
International Paper Company Mobile 9, Alabama	Samuel W. Jenkins Southern Kraft Division
International Resistance Co. 401 North Broad Street Philadelphia 8, Pennsylvania	Walter J. Gershenfeld Personnel Manager Central Office
Johns-Manville Corporation 22 East 40th Street New York 16	Ledwith J. Brennan Director of Training
Kennecott Copper Corp. 161 East 42nd Street New York 17, New York	John D. East Assistant to the President
Louisiana Power & Light Company 142 Delaronde Street New Orleans 14, La.	W. H. Senyard Director of Personnel
Marquardt Aircraft Company P. O. Box 2013, South Annex Van Nuys, California	J. T. Dale, Manager Professional Personnel
Monsanto Chemical Company St. Louis 4, Missouri	Robert F. McCoole Technical Personnel Manager
Northern Illinois Gas Company 615 Eastern Avenue Bellwood, Illinois	R. A. Lightbody, Director Management Development
Philadelphia Electric Co. 900 Sansom Street Philadelphia, Pa.	G. L. Harvey, Jr. Director, Employment Div.
Philco Corporation Philadelphia 34, Pennsylvania	Charles Lupton Manager, College Relations
Phillips Petroleum Company Bartlesville, Oklahoma	D. R. McKeithan, Director Technical Manpower Division
Public Service Electric & Gas Co. 80 Park Place, Newark 1, N. J.	M. D. Hooven Electrical Engineer
The Pure Oil Company 35 East Wacker Drive, Chicago, Ill.	J. J. Stadtherr Training Director
Radio Corporation of America Camden 2, New Jersey	Charles R. Vennel, Jr. College Relations
Rohm & Haas Company 1700 Walnut Street Philadelphia 3, Pa.	John C. Haas Vice President

Company	Contact
Scott Paper Company Chester, Pennsylvania	Richard B. Miller Manager of Corporate Employment
Shell Development Company Emeryville, California	Mott Souders Director, Oil Development
Swift & Company Union Stock Yards Chicago 9, Illinois	E. D. Hall, Head Personnel Division Research Laboratories
Sylvania Electric Products, Inc. 1740 Broadway, New York 19, N. Y.	Harris Reinhardt Manager, Organization Development
Toledo Edison Company Toledo, Ohio	Frank W. Keith, Director Employee Relations

MEMBER ASSIGNED TO NATIONAL SCIENTIFIC POST

James R. Killian, new Eisenhower appointee as Special Assistant to the President of the United States for Science and Technology, is a former Vice President of ASEE and a member since 1939. He is succeeded as President of the Massachusetts Institute of Technology by Julius A. Stratton, former Chancellor of MIT and ASEE member since 1950.

INDUSTRIAL FELLOWSHIPS, 1957-58

The establishment of the third ASEE Industrial Fellowship by the Leeds and Northrup Foundation has just been announced. The fellowship is for one year of graduate study in mechanical, electrical, or chemical engineering. The $3,000.00 grant is paid by ASEE to a school selected by its Industrial Fellowship Committee. One-half of the grant, or $1,500.00, goes to the student selected by the school; the remaining $1,500.00 is retained by the school to compensate for its cost of instruction. This division of funds between the school and the student is the unique and highly desirable aspect of this fellowship plan.

The recipient receives the award for an initial year of graduate study. If his work is of high quality the fellowship is renewed each year for two additional years so that a doctorate degree ultimately may be obtained.

A brochure describing the plan now is being prepared and efforts will be made to interest other foundations and industries to establish similar programs. All inquiries should be directed to Karl B. McEachron, Jr., Chairman of the Industrial Fellowship Committee, or to the Secretary of the Society, W. Leighton Collins.

The continued support of the program by the Leeds and Northrup Foundation is greatly appreciated by the Society, the selected institutions, and the recipients.

ORIENTING FRESHMEN TO THE EXPERIENCES OF ENGINEERING COLLEGE

HERMAN A. ESTRIN

Associate Professor of English
Newark College of Engineering
Newark, New Jersey

Teaching English in an urban engineering college has given Professor Estrin a keen awareness of the freshman's personal, social, and academic problems in adapting to the discipline of engineering studies. A program similar to that described herein could well be followed at larger institutions.

What are the uncertainties and fears of a prospective engineering student?

Once he matriculates as a freshman, what are his most urgent problems?

What is likely to be lacking in his high school preparation for college?

These and similar questions were answered by a questionnaire presented to four hundred freshmen at Newark College of Engineering. Their answers provided many insights that led to a more effective orientation program at NCE. The student handbook was revised to serve the students' needs, faculty advisers obtained useful background information, and the study provided pertinent data to the Committee on Articulation between High Schools and Colleges.

Questionnaire Responses

Students ranked their problems and fears before entrance to engineering college in the following order: financial problems, fear of too much homework, lack of knowledge as to what is expected of the student, and lack of ability to study. They were also concerned about their degree of academic success, and the lack of proper high school background. Many students were uncertain about their choice of engineering as a profession, and worried about the lack of time for study, the lack of campus life, and transportation difficulties. Lesser problems were uncertainty as to choice of college, entry into the armed forces, and acceptance by fellow students.

Their most important problems as engineering students seemed to be an inability to concentrate and to study effectively, insufficient time for study, inadequate finances, and inadequate parking facilities on the campus. The large amount of homework, difficulty of the subject matter, low grades, and inability to obtain employment or to participate in extracurricular activities were also problems. Others were social adjustment to college life, personal adjustments to instructors and students, status in the armed forces, and again, transportation.

More than sixty per cent of the students agreed that their high school preparation neglected the development of correct study habits. Twenty-five per cent stated that the high schools failed to offer proper guidance to a college selection, and as many stated that their high school background in mathematics, chemistry, physics, English, and history was insufficient. Nearly twenty per cent indicated that high schools did not offer effective instruction and did not provide them with a realistic approach to college. Others mentioned that social and extracurricular experiences were

lacking in their high school preparation.

Questions concerning the value of the freshman orientation program received generally favorable responses and brought out a number of constructive suggestions. Students thought the program helpful in acquainting them with the college community—its physical plant, its aims and philosophy, its traditions, facilities, and resources. Orientation also enabled them to meet members of the administration, faculty advisers, and student leaders, and aroused their interest in extracurricular activities.

Two comments suggesting improvements in the orientation program were especially interesting. One freshman said, "I would tell them that NCE requires hard work and long hours of study. A freshman should have strict adherence to engineering principles." Another wrote, "Students direct from high school lack training in doing homework and taking notes. More emphasis should be placed on those techniques at high school, for they seem to be the biggest hurdles to jump in college."

Other significant suggestions were as follows:

Explain the value of good study habits and diligent study.

Describe the relationship of student to professor.

Explain what the college and the faculty expect of a student and what he can expect of them.

Explain how to develop effective reading habits and take good notes.

Give the student more problem—solving techniques.

Encourage the student to relax and mix with others.

Provide more opportunity for students to meet the faculty socially.

Suggested improvements of the student handbook included better maps of the buildings on campus, a list of instructors for freshman subjects, a discussion of the content of freshman courses, more concrete suggestions for adjustment to college, and more specific hints on homework.

The views of these four hundred freshmen were incorporated in subsequent orientation programs, and the administration also arranged to have freshmen parents visit the college. "Parent's Night" successfully provided a further means of aiding freshman orientation to college life and work.

Parents Night at an Engineering College

Parents were greeted at the college by newly elected members of the Freshman Council, and were presented with an edition of the college newspaper in which an editorial was addressed specifically to them. The program opened with a panel discussion in which the President, the Dean of Administration, the Dean of Students, a professor of Air Science and Tactics, and spokesmen for Industrial Relations, Testing and Guidance, and Student Aid participated.

These authorities discussed the philosophy of engineering education, its curriculum, its extracurricular activities, the Selective Service regulations, the function of the Air Force Reserve Officer Training Corps, and the counseling and guidance services. The panel also explained the changes in an adolescent's philosophy of living and studying as he matures during the college years, and the problems of personal and professional development faced by engineering students.

The discussion session was then opened for informal questioning which brought out such parental questions as these:

Why does my son have to study so much and so long during the week?

In what extracurricular activities can he participate?

Of what value are these activities to him?

Why does he have to study chemistry when he plans to be an electrical engineer?

What is meant by, "marking on the curve"?

Should my son join the ROTC?

How can my son earn financial aid to pay part of his expenses at college?

Later, parents were given an opportunity to learn something about the course content of the various engineering curricula. Exhibits of physics, mathematics, English, chemistry, personnel relations, and air science materials were displayed. While viewing the exhibits, parents met their sons' instructors, discussed the subject matter of engineering courses, and became acquainted with the texts, visual aids, and tools their sons would use during their college years.

Parents' Night at NCE was successful for many reasons. It enabled parents to see the variety of social, athletic, literary, and professional activities which take place at the college; it brought parents in direct contact with the faculty and administration, and acquainted them with the philosophy and content of an engineering education; it prepared parents for changes in the adolescent's social, intellectual, and physical make-up; it demonstrated the role which the college plays in the placement of its graduates, and informed parents of the regulations governing selective service. Most important, it answered urgent questions in the minds of parents, gave them a feeling of belonging to the college, and better equipped them to share their son's college experiences and to understand and encourage his professional development.

SHORTAGE OF ENGINEERS DISCUSSED AT SECTION MEETING

The National Capital Area Section of ASEE met during October in McMahon Auditorium of The Catholic University, Washington, D. C. Attendance included 31 members and 12 guests.

The program presided over by Chairman D. E. Marlowe was devoted to a discussion of *The Demand and Supply of Scientific Personnel,* by Drs. George Stigler and Blank. Thomas J. Mills, Program Director for Scientific Manpower, National Science Foundation, summarized the book. Harold Goldstein, Assistant Chief for Analysis, Department of Labor, discussed the statistical methods used, and commented on factors other than economic considerations that could make for a shortage of engineers. Mr. Kenneth Borgen, Industrial Manpower Specialist, Navy Department, then gave the non-free-market approach to the subject. He pointed out the scientific advances that have increased the number of man-hours required to carry out technological activities.

Nuclear Energy Education Report No. 2

OBJECTIVES AND EDUCATIONAL PROGRAMS IN NUCLEAR ENGINEERING EDUCATION

COMMITTEE ON ATOMIC ENERGY EDUCATION

Foreword

With the marked impetus given to the nuclear field in the last few years there are developing new pressures on an already critical manpower situation, and there are many indications that these pressures will increase. The shortage of engineers on a nation-wide scale is emphasized in the nuclear field where so few training facilities are available, and where the need is so acute for men qualified to assist with the planning, design, development and operation of processes and systems involving nuclear transformations. The applications and potential applications in stationary and mobile power units, chemical processing, process control and industrial operations such as radiography and thickness gaging have increased phenomenally in the last few years and all indications point toward an even more rapid increase in the immediate future.

In recognition of this mushrooming need for trained manpower the Atomic Energy Education Committee of ASEE inaugurated a series of studies to provide information to those institutions considering the training of students in this field. One of these studies presented information on the activities of the colleges and universities in providing the necessary training in the field (1).* The training phase of the study reported herein is directed toward an analysis of the types of training needed and methods of providing that training.

Responsibility of Educational Institutions in Providing Training

Initially, and as the field began to develop, virtually all training was in the national laboratories. The need for secrecy in the early days of the Manhattan project and other pressures precluded the development of general educational programs. After the end of the war, and with the availability of principles and certain data a training program was established at Oak Ridge National Laboratory. Not long thereafter a few colleges and universities began to offer courses and curricula in the nuclear field. More recently, Argonne and Brookhaven National Laboratories have made available some of their facilities for formal training programs in certain areas. These and other installations have cooperated with educational institutions on special programs, particularly in assisting with facilities for thesis research in graduate study.

However, the time is rapidly approaching when it can no longer be assumed that the national laboratories can give attention to formal training programs. The real and major responsibility for nuclear engineering

* Numbers refer to references at end of report.

education must rest with the colleges and universities, whose basic function is to provide educational apportunities in significant areas.

Not all of the responsibilitiy can be assumed by the schools at the present time, nor should it be so assumed. A transition period is essential.

The national laboratories can continue to play an important part in the over-all program by providing specialized facilities for research or advanced work particularly where these facilities are beyond the budget of the average engineering school.

The importance of industry in the training program must not be overlooked. In this field, as in many others, it is apparent that on-the-job training must be expanded. Frequently, this training will be strictly applications procedures which are unsuitable as curricular material but which are extremely important in design. However, it will be expected that the colleges and universities, and the technical institutes as well as the national laboratories, will cooperate with industry in such training programs.

The Committee is in no sense urging that every school consider introducing a full-fledged program in nuclear engineering. In fact, relatively few schools are justified in so doing. What is being urged is that every school consider how it, in the light of its local and special situations, can contribute to the present urgent needs of industry and the nation. The contribution may range from the introduction of a small amount of applications in various engineering courses to a full Ph.D. program, for there is a wide spectrum of application. One of the purposes of this report is to point out the wide variety of ways in which educational institutions may participate in the training of engineers to function intelligently and effectively in this nuclear age.

In this light, it is not the purpose of this report to provide a definitive answer to the question of whether or not there should be devised new undergraduate or graduate curricula which will lead to degrees in nuclear engineering (and, therefore, to the use of the term "nuclear engineer" in describing such graduates). Many of the points of view presented will bear on this question, but there is an obvious need for further consideration of this matter. The experience gained in various schools and in industry will help in answering the question.

Definition of the Field

For the purpose of this report, nuclear engineering is defined as the application of the physical and life sciences to the design of engineering systems involving nuclear energy and composed of circuits, processes, energy converters and structures, and the prediction of the behavior of such systems in terms of time, cost, men, and materials. Thus, nuclear engineering is closely allied to the conventional engineering fields. In fact, it is frequently difficult to draw a sharp line of demarkation between nuclear engineering activities and those of mechanical, electrical or chemical engineering. However, it is presumed that if nuclear transformations are involved in the system under consideration the function can be considered to involve nuclear engineering as well as conventional engineering.

Activity Classification in Nuclear Engineering

From the preceding definition, it is apparent that a wide range of training facilities must be provided to assure the progressive development of the general field. In order to analyze more effectively the educational re-

quirements, the broad spectrum of activities indicated in the definition was considered to include six primary functions—(1) operations, (2) engineering administration and management, (3) engineering design, (4) engineering development, (5) research, and (6) teaching. Although the boundaries between certain of the functions may not be sharply delineated in all cases, the fact remains that these are the jobs to be done and the areas in which personnel must be somehow trained.

1. *Operations.* This classification includes those activities associated with the control and handling of nuclear plants, processes, and materials. Activities such as reactor operation, routine materials inspection by radiography, certain phases of health physics duties, and programmed chemical processes are included in this classification. While an understanding of the basic scientific and engineering principles involved in the processes is highly desirable, it is not essential to the proper performance of assigned duties. In general, the individuals involved in these activities would be considered to be technicians rather than engineers or scientists, and training at a technician's level is a minimum requirement.

Training for these functions can be done most effectively in the long run through the technical institutes or through on-the-job training by the specific industries concerned. However, the colleges may assist through short courses and similar non-credit instructional programs. The number of people required for this class of activity is expected to increase rapidly as the use of nuclear power increases and as new facets of the non-power applications are developed.

Supervision and management personnel in operating plants are, in most cases, scientific or engineering graduates and will receive their basic training through normal college or university disciplines.

2. *Engineering Administration and Management.* As used in this report, this classification includes those administrative functions, such as the formulation of policy, arising from the participation of an organization in any phase of the nuclear program. The individuals included in this classification are officials of public utilities, equipment manufacturers and suppliers, producers of materials and products into whose processes nuclear techniques might be introduced effectively, college and university administrators, and others whose duties do not require a detailed understanding of nuclear phenomena, but who do need some understanding of the scope and limitation of applications.

The information required by these individuals may be acquired through published material to a certain extent and through competent engineers and scientists in their organizations to a greater extent. However, the interpretation of the facts which they require may be gained effectively through conferences, workshops, or short courses.

The number of individuals who could profit by training of this type can only be estimated at best. However, it may be expected to reach a peak in the next four years and then to decline rapidly as individuals trained originally for other functions enter the organizations and rise to administrative positions.

3. *Engineering Design.* This classification includes those engineering activities involved in the utilization of principles and available data for the purpose of altering, modifying, or improving circuits, processes, equipment, structures and other products to improve their operating characteristics or to adapt them to a specific

application. In this area lies the bulk of the engineering functions. Activities such as the determination of thickness of shielding, details of electromagnetic pumps, selection of proper coolant and adaptation of electronics to solving control problems are examples of engineering design that may be associated with the power reactor field. Many examples exist in the non-power field as well.

For training men to function as engineering designers there is no substitute for a well-organized and well-taught engineering curriculum followed by experience in design. The specific nuclear information required can be obtained in a variety of ways, ranging from on-the-job training to special M.S. or possibly Ph.D. programs in nuclear engineering.

4. *Engineering Development.* In this classification fall those activities associated with the translation of basic relationships and data into new systems, processes, equipment, or products. It involves creative design, inventiveness, and similar attributes necessary for the metamorphosis of an idea into a working model. Out of these activities come the new applications of the science.

One facet of the training of men to function in engineering development is the acquisition of a real understanding of the basic principles of the underlying sciences and this may be accomplished through educational programs in the colleges and universities. Of equal importance is the fostering of the creative spirit. An atmosphere in which the creative ability of the individual is encouraged appears to contribute significantly to the development of new engineering products and processes.

5. *Research.* The term research denotes those activities associated with the establishment of new data and the formulation of new principles. Research that will be significant in the nuclear engineering field may originate in chemistry, mathematics, physics or any of the branches of engineering. Training for research is usually considered to be through the channel of graduate study in the chosen field, but this is by no means the only way in which the desired end may be obtained. For example, industry and the national laboratories make important contributions in the training and development of research personnel, and postdoctorate research assignments in these organizations can be extremely effective in the development of an individual.

6. *Teaching.* Desirable training for college teachers in this branch of engineering closely parallels that suitable for research.

Objectives of Education in the Nuclear Engineering Field

Because of the wide diversity of activities in the field, it is obvious that many patterns of training must be utilized in attaining the over-all objective of providing the nation with an adequate number of persons well trained in the discipline of nuclear engineering. It is expected that each institution involved in training in this field will have its own set of objectives in harmony with the over-all objective. For example, some will aim at providing people with educational backgrounds best adapted for contributing in the research and development area, while others will aim at providing educational curricula and experiments that will enable their students to contribute in the design and administrative areas.

In considering the respective roles of the colleges, technical institutes, industry, and the Atomic Energy Commission in providing nuclear engineering education, two factors

unique to the area under consideration are pertinent.

1. Nuclear engineering is not a new and separate field of technology, isolated from other fields of science and engineering, but is a field which depends on and derives from the older orthodox fields of technology with the added requirements imposed by the peculiar nature of nuclear phenomena. In one sense, nuclear engineering is the application of each and every one of the well-known disciplines of science and technology to the exploration, design, and manipulation of nuclear systems.

2. An obvious corollary to this factor is the fact that no one individual can be expected to be an expert in all of the areas of nuclear engineering. At the beginning, he can hope for little more than an understanding of the practical implications and requirements of nuclear phenomena in one or a few practical areas of science and engineering, with a more or less general comprehension of its implications for other areas related to the ones of his particular interest.

Thus the development of a course or a program of study in nuclear engineering involves recognition of the fact that a sound foundation in the fundamentals of the basic sciences and engineering is essential for engineers in the nuclear field. This requires that a nuclear engineer receive the usual training in one, or in portions of more than one standard field of science or engineering closely related to nuclear engineering.

In addition to the basic training in science, the nuclear engineer requires an understanding of the fundamentals of nuclear phenomena and the implications of these phenomena in practical situations. The depth of understanding and the breadth of the implications must increase with an increase in the technical level of the activity classification. The only feature of nuclear engineering education which is new and different from usual technical engineering educational programs is the addition of the fundamentals of nuclear phenomena and their implications.

With respect to pedagogical perspectives, two additional observations are pertinent.

(a) The amount of special training in nuclear fundamentals and the practice required by different students may vary widely. A few courses may satisfy the need of those having interests in certain areas in the nuclear engineering field. To perform satisfactorily in other areas, several years of specialized study accompanied by extensive practice are necessary. Between these extremes there are all levels of requirements.

(b) At present, colleges do not possess adequate equipment and facilities nor do they support sufficiently extensive research and development projects to offer the practical experiences in nuclear engineering commensurate with the requirements of higher levels of specialization in the field. It is expected that this situation will continue indefinitely in the future to a somewhat larger degree than in most other technical fields.

Hence, the training of nuclear engineers must include participation in the activities of AEC laboratories and industries, where facilities for practical experience do exist. Thus, it follows that if the colleges and universities are to assume the major responsibility for this field of training, as they have for other fields (with whatever assistance is necessary being supplied by the AEC and industrial organizations) their objectives will include three major areas.

(a) Offering courses in nuclear fundamentals and practices in selected areas of the nuclear engineering field, consistent with the interests and abilities of their staff, and the needs, interests, and opportunities of students.

(b) Acquiring equipment and facilities to support these courses.

(c) Maintaining cooperative endeavors with industrial and governmental laboratories in providing maximum opportunities for practical and maturing experiences for students in the field.

The Government Laboratories can contribute in two ways.

(a) Providing specialized instruction and practical experiences for students in areas which the colleges are not equipped to provide.

(b) Encouraging the development of appropriate instructional and practical opportunities in colleges and minimizing their own programs in these areas as the colleges become able to meet the needs.

The general role of industry in the educational program is to encourage the schools to concentrate on the broader aspects of training. This may be done by providing on-the-job training for operational and specialized technical requirements which would relieve the schools from this burden.

Attainment of these Objectives in the Schools

The objectives indicated are qualitative in nature rather than quantitative. That is, the contribution of a school in the field of nuclear energy education is properly judged by the degree of understanding at the prescribed level attained by the students rather than by the number and variety of offerings. In some instances the courses will involve simply the transmission of information, as in short courses. In other situations, the emphasis may be on the development of manipulative skills; but more often, mastery of principles and facility in their application will be involved.

Thus, colleges and universities may make significant contribution to the training of nuclear engineers in a wide variety of ways, and those contributions may be made at several levels as indicated in the classification of activities earlier in this report. The greatest resultant contribution will result when each institution involved in the field develops a program best adapted to its staff, equipment and students. It is obvious that these factors will change with time; hence, it is to be expected that the programs of the individual schools will be dynamic. Unquestionably, standardization of programs and standardization of techniques are to be avoided.

It should be noted that there are at least three different techniques of presentation of material in the nuclear energy field. One technique is that of incorporating appropriate material in the subject in the usual undergraduate courses in science and engineering. One example of this is the consideration of radiation damage in a course in engineering materials. This requires on the part of the instructor an interest in and an understanding of the field and its applications to a degree not presently possessed by many engineering teachers, but it is an extremely effective technique for making important cross ties between the nuclear field and the conventional engineering fields.

A second technique for introducing the material into the program of the students is that of modifying courses to make room for a connected consideration of certain phases of nuclear energy. For example, several periods

might be spent in a conventional heat-transfer course on a consideration of the heat-transfer characteristics of liquid metals of potential value in reactor cooling systems. This technique involves removing some material from the existing course in order to make room for the new material, and consequently will not be enthusiastically received by many instructors who feel they have inadequate time for the presentation of the material now in their courses and all of which is fundamental, basic and absolutely essential.

The third technique consists in the development of new courses in nuclear energy and its applications. In general, this is probably more acceptable to the teachers of individual courses and less acceptable to the curriculum builders than other techniques. The elimination of one well-established course in a curriculum to make way for a new course is not easy. If only one new course is involved it may be fitted in as a senior elective or as a single substitution, but if several new courses are involved the alternatives are to develop the sequence as an additional year, or to develop a separate undergraduate curriculum in nuclear engineering. It may be observed that in general the additional sequences are being developed as graduate rather than undergraduate majors.

Probably most institutions developing programs in the nuclear energy field can use advantageously all of the techniques—infiltration, substitution, and development of new courses. Experimentation with all of these techniques should be considered.

In discussing the techniques it has perhaps been implied that the contribution of the institution will be made through the medium of resident instruction. Although this will usually be the case, it is by no means the only possibility. Many schools have extension activities, such as short courses and off-campus instruction. These may be used to excellent advantage over a portion of the spectrum of training requirements. At the other end of the spectrum, training in research in the field is possible at a few institutions having special facilities or which are closely associated with government laboratories, as is Iowa State College.

The objectives of acquiring equipment and developing and maintaining cooperative endeavors with off-campus organizations may be approached in many ways. As is noted in a separate section of the report, the Atomic Energy Commission is sponsoring an extensive program of college assistance in procuring equipment. The problem of securing financial aid from conventional sources is by no means new to college administrators, and cooperation between industry and schools in placement and utilization of personnel is not unique to the nuclear energy field.

Administration of the Program

The breadth of educational objectives, not all of which will be pursued by any one institution, and the variety of valid methods by which each can be sought, preclude any unique solution to the problem of how the program should be administered. In general, the administrative pattern should be built around men and men should not be forced into a preconceived mold. The variety of effective administrative practices can be illustrated by some patterns which have already developed.

These range from complete self-sufficiency in a nuclear department (or nuclear section of an existing department) to committee-directed cooperative effort crossing departmental or even divisional lines. The trend to self-sufficiency is exemplified at

North Carolina State while Purdue and Michigan are examples of schools in which the cooperative approach is effective.

A single educational program profits by centralized administration but usually appeals to a narrower segment of students. For example, if reactor core designers are to be the principal product of the course, the administrative as well as the curricular pattern may be quite different from that in a program of broader objectives.

The administrative pattern is sensitive to the policy decision on the level and scope of nuclear instruction—such as undergraduate only, courses at the graduate level for a Master's degree without a nuclear thesis, Master's degree with nuclear thesis, doctoral programs, or extensive post-doctoral and faculty research. The initial administrative pattern in a given institution should reflect the initial policy decision on this question, but the pattern should be kept flexible if the scope of the activity is expected to change.

The administrative pattern will also reflect the extent to which the program includes extension, evening, or other courses which meet limited objectives.

Costs

The problem of cost of a program in nuclear engineering and the supporting science is of direct concern to the universities. Obviously the capital and operating costs will depend upon the extent of the program developed. Direct salary costs for classroom instruction are readily evaluated. Laboratory instruction and thesis instruction costs, exclusive of equipment, follow the same pattern as other disciplines, except for special health and safety expenses that may be necessary where radioactive materials are involved. In an extensive program, several additional employees may be required.

The cost of equipment for demonstration and laboratory experience varies from a few hundred dollars to several million dollars and, again, the needs of the individual institution will predicate the sum to be spent for equipment. A few general remarks may be of assistance, however, to those institutions planning to start some work in the nuclear energy field (2).

Successful courses can be given in the theoretical aspects of nuclear science and engineering with no demonstration or laboratory equipment. However, it is the opinion of this committee that laboratory experience makes the theoretical aspects of the field much more meaningful. The average engineering student is accustomed to think in terms of physical realities that can be measured, and for him laboratory experiments are valuable.

For an expenditure of about one thousand dollars an institution can obtain low-strength sources and counting equipment that will make possible a variety of simple demonstrations or laboratory exercises in radiation, shielding, and counting techniques.

For a Master's degree program in nuclear engineering additional equipment is highly desirable. Items such as an exponential assembly, a hot loop for heat-transfer experiments, equipment for demonstrating chemical separation techniques, and radiation and shielding facilities with the necessary auxiliary equipment will require a total expenditure between ten thousand and one hundred thousand dollars, depending on the level and complexity of the systems.

A reactor suitable for teaching purposes will cost upward of one hundred thousand dollars and a reactor suitable for research at high flux

levels will require a capital investment of one or more million dollars. The annual operating costs for a high flux research reactor will be many thousands of dollars.

In this respect, it has been emphasized that there is no single most desirable program in nuclear engineering and it should also be emphasized that there is no single minimum optimum or maximum equipment requirements. Equipment compatible with the interests and abilities of the staff is highly important.

Sources of Assistance

Much has already been written about sources of financial assistance. In general, educational institutions must be prepared to pay instructional salaries and to provide building space. The Atomic Energy Commission has a generous program of assistance in special nuclear materials for instructional or research programs, or both, for reactors, exponential experiments (sub-critical reactors) and other equipment for laboratories or instruction. In these programs competence of the academic staff is a prerequisite to the government support.

The Commission has sponsored several programs for faculty members, ranging from conference and summer institutes to periods of research experience. In some of these programs the National Science Foundation has cooperated.

Indirect support to campus programs comes from a number of related fellowship programs. AEC supports fellowships in reactor technology and in radiological physics. NSF Fellowships (pre-doctoral and post-doctoral) cover a number of fields, including engineering. A substantial number of foreign governments may be expected to send students to be trained in nuclear programs in American engineering schools.

The various AEC programs of assistance in this field have been widely announced by letters to the administrative officers of all accredited engineering schools and in the scientific periodicals. Further information can be obtained from the Office of the Director of Reactor Development or of the Director of Research, AEC, Washington 25, D. C.

Both the AEC and NSF have supported campus research projects in the nuclear field, either by providing research facilities, supporting their operation, or both. In general, this support favors projects conceived by faculty members and minimizes the subcontracting of Commission activities.

So far support from industry and private foundations has been limited to a few projects, but these obvious sources should not be overlooked.

Staff Requirements

The importance of the staff in a program in the nuclear field, as in other fields, cannot be overemphasized. A well-trained and enthusiastic faculty can develop a good program with a minimum of equipment, but elaborate facilities will not compensate for mediocre staff members.

With the wide diversity of approaches possible in developing strong programs in the field and with the broad scope of the field, it is apparent that a complete staff in nuclear science and engineering will consist of several individuals with diverse specialties. Men in physics, chemistry, mathematics, and several branches of engineering will be involved in the over-all training of the students. The major interests of many of these individuals will be in areas other than nuclear engineering, but if the program in nuclear engineering is to be successful it is obvious that all staff members associated with the program must have a sympathetic interest in

the aims and objectives of that program.

The problem of attracting and retaining competent staff in the basic sciences upon which the nuclear engineering program depends is not easy, but the supply of individuals trained in these areas upon which the colleges may draw for staff is much larger than the supply of men trained or experienced in the field of nuclear engineering. At the present time, therefore, the major source of staff for the nuclear engineering portion of the program consists in engineering graduates who have had special training in nuclear technology or first-hand experience with some phase of the various nuclear energy programs.

The first-hand experience that is invaluable at this stage of development of courses and laboratories can be obtained through the usual channels of industry, through work at one of the national laboratories, or through participation in research. While men with the desired qualifications may be attracted to educational institutions, many institutions may find it more expedient to make it possible for qualified staff members in engineering to take advantage of the special experience programs made available during summers. Summer Institutes, summer employment by industry in the nuclear energy field, and summer employment by the national laboratories all provide means of obtaining the quality of experience that will bring vitality and breadth of outlook to the instructor in classroom, laboratory, and direction of research.

Conclusions

It is the intent of this report to indicate the wide scope of activities falling within the general area of nuclear energy and its applications. Because of this wide range of activities, an equally wide range of educational programs is required to meet the manpower needs and these programs involve the cooperation of colleges and universities, of technical institutes, of the government laboratories, and of industry.

No single program or pattern of development of courses for the colleges and institutes is advocated. To the contrary, each institution is encouraged to experiment with arrangements and procedures that appear to be most fruitful in the light of local conditions. The Committee firmly believes that many useful programs may be developed along different lines by various faculties.

Finally, in this area of nuclear education, as in other areas, the key to progress lies in the individual faculty members and their talents for educating and inspiring their students.

REFERENCES

1. "Nuclear Energy Education Report No. 1, Nuclear Engineering Courses in the United States, 1955." Committee on Atomic Energy Education, American Society for Engineering Education, 1956.
2. "Suggested Programs and Cost Estimates for University Instruction in Nuclear Science and Engineering." Frank E. Myers, Lehigh University, Printed by Argonne National Laboratory, 1955.

EJC OFFICERS, 1958

President: Enoch R. Needles
Vice President: O. B. J. Fraser

MINUTES OF THE EXECUTIVE BOARD MEETING

Chicago, Illinois

September 8, 1957

The September meeting of the Executive Board was held in Chicago with all members of the Board in attendance and President F. C. Lindvall presiding.

Report of the Secretary, *W. Leighton Collins*

a. *Summer Schools*

1. *Humanistic-Social Summer School Solicitation of Funds.* It was agreed President Lindvall should continue his negotiations with NSF officials to determine their interest so that a formal proposal can be submitted for the summer of 1959.

2. *Funds for Chemical Engineering Summer School Proceedings.* The NSF did not approve the request for funds, and so no matching allocation from ASEE is required. It was agreed an attempt be made to obtain the best papers for publication in the JOURNAL.

3. *Papers from Mathematics in Engineering Institute.* The Executive Board *VOTED* to instruct the Secretary to write to the responsible parties requesting that the papers be submitted, as previously agreed, in order that the financial account can be closed at the end of the fiscal year.

b. *Publication of A New Industry's Stake in ASEE.* The Executive Board agreed with the Industrial Membership Committee as to the need for a brochure to be used in expanding membership and *VOTED* to approve $300 to $500 for printing about 5,000 copies, the amount to come from unallocated surplus or charged to supplies and printing if the year's operation shows no deficit.

c. *Roster of Graduates for Engineering Societies.* Requests from engineering societies for lists of graduates are being received by some schools. Since it is the present policy of most colleges not to give out such lists, and since it was believed adequate contact with graduating seniors is maintained through student chapters, where they exist, it was agreed to refer the matter to ECAC for consideration.

d. *Annual Meetings*

1. *Accident at 1957 Annual Meeting.* The insurance coverage of the Society was reviewed and it was agreed the Society had no responsibility for property damage to an automobile, for that is the type of risk frequently accepted as a matter of personal choice and routine.

2. *Annual Meeting Registration Fee and Budget.* A favorable balance of about $250.00 remained in the Annual Meeting fund even after the $1,400.00 for underwriting the banquet tickets to retain a $4.00 per person cost was charged to the account. It was agreed that the experiences of the past two years did not indicate the $4.00 registration fee was inadequate, but action was deferred until the Annual Meeting Committee studied the problem in detail, particularly as it pertains to women and children.

3. *Tickets for Those at Head Table at Annual Banquet.* After considerable discussion it was agreed that: (a) The cost of banquet tickets for award winners and wives, and Society Award Committee chairmen and wives, be charged to the respective

awards; (b) The Society pay for banquet tickets for the President, Secretary, Banquet Speaker, President of the host institution, and their wives; (c) All others at the head table purchase tickets for themselves and their wives. It was further agreed that for the Annual Meeting the Society pay for adequate housing for the President and his wife.

4. *Conflict of Applied Mechanics Division of ASME with Pittsburgh Annual Meeting.* This was reported for information only.

5. *1961 Annual Meeting.* The Executive Board *VOTED* to accept the invitation of the University of Kentucky to hold the 1961 Annual Meeting on its campus.

6. *Preliminary Plans for the 1959 Annual Meeting.* W. I. Short, co-chairman of the local committee, reported that preliminary negotiations with several major industries in the area indicated an enthusiastic desire to cooperate as "industrial hosts" in developing plans which will take advantage of the extensive research laboratories of the area. The Executive Board instructed the local committee to continue with its plans to such an extent that details can be presented to Divisions and Committees prior to the 1958 Annual Meeting in order that the necessary deliberations and actions can be taken at the Annual Meeting.

e. *Mid-winter Division Meetings.* The following schedule was announced and it was agreed that at least one member of the Executive Board attend each meeting.

1. Cooperative Engineering Education, January 9–10, Dallas, Texas.
2. Engineering Drawing, January 15–17, General Motors Institute, Flint, Michigan.
3. College-Industry Conference, January 30–31, University of Michigan, Ann Arbor, Michigan.

f. *Board Attendance at Section Meetings.* It was agreed that insofar as possible, a member of the Executive Board attend each Section Meeting. A tentative schedule was developed. It was also hoped that the Sections would recognize the Board Members and give them an opportunity to comment informally about recent developments in the Society and its work. The Executive Board *VOTED* to hold its spring meeting with the Southeast Section at Miami, Florida on April 17–18.

g. *Enrollment Statistics.* The slowness of some schools in reporting data last year and recent correspondence with H. H. Armsby were discussed. It was agreed there was no excuse for lateness and that ECAC would follow-up any delinquencies in order to get results. It also was agreed the data should be published in February. The possibility of ECAC distributing a preliminary summary of the report also was discussed.

h. *ETS, Aptitude Tests.* The number of requests for such information and tests is to be used after the second year of college is increasing. It was agreed to ask Dean R. Roy for a report of the work of ETS in this general area and to refer the entire problem to ECAC for study.

i. *Yearbook Data Card and Nomination Form.* A triple postcard is being used, a separate return card for each purpose.

j. *Purchase of Equipment.* The Executive Board *VOTED* approval of the purchase of a 4-drawer file for the office of the Secretary and a cardex file for the office of the Editor. Purchase of a postage meter and folding machine is being studied.

k. *Office Staff.* Almost a complete turnover will occur within a few weeks, entirely due to the normal course of events.

1. *Copies of Journal for Students.* Plans have developed for the sale of JOURNALS at the special price of $1.50 per year (excepting the *Yearbook*) to students participating in faculty-sponsored discussion groups. The JOURNALS will be sent to the sponsor upon the receipt of the names of participants and the payment of the required amount of money. The CYET will seek sponsors and deans will be asked to encourage the program.

Report of the Treasurer, *John Gammell*

a. *Audit.* The principal features, such as the favorable balance of about $6,500.00, were discussed. The audit will be published in the *Yearbook.*

b. *Award Accounts.* The separate accounts established for each award indicate that it costs between $700.00 and $1,000.00 to administer an award. The inadequacy of the receipts for the Lamme and Westinghouse awards was discussed. It was agreed to refer to the Financial Policy Committee a study of the nature of the investment of the Lamme funds, the type of agreement, and the desirability of having the fund invested so as to yield a higher return.

c. *Bank Signatures.* The Executive Board *VOTED* that the President's signature be added to those of the Secretary and Treasurer so that in case either of those officers were incapacitated the President's could be the second signature on checks; the resolution is to be worded to comply with the bank requirements.

d. *Investment of Society Funds.* All Society funds are invested in U. S. Government bonds or savings accounts, as recommended by the Financial Policy Committee. An additional $10,000.00 has also been deposited, $5,000.00 in each of two savings accounts paying 3% interest; this includes the reinvestment of $700.00 of U. S. Government bonds having come due in June.

Reports of Vice Presidents

a. *ECAC, Ralph Morgen*

1. *Termination of Engineering Students by Means Other than Graduation.* The Executive Committee of ECAC considered the problem and decided that the termination of engineering students' careers was no different than for any other group of students, and that consequently the problem should be referred to the American Council on Education. It was agreed the Secretary should make this referral.

2. *Committee Duplication.* Since the Manpower Committee of ECAC is to be continued with a shift in emphasis from students to faculty, since loss of faculty is a manpower problem, and since there is much duplication of personnel between the Society's Loss of Faculty to Industry Committee and ECAC's Manpower Committee, it was agreed that having the former functioning within the framework of the latter be given serious consideration next year, and that the Chairman of the Manpower Committee now be named to the Loss of Faculty Committee as well.

b. *ECRC. R. J. Woodrow*

1. *1957 Review of Current Research.* It will be available shortly.

2. *Survey of Research Capabilities.* Data were collected during the summer according to schedule, and the suggestion was made that plans for publishing the report should be made in the near future.

3. *Overhead Charges in Research Contracts.* Because overhead charges of only 15 per cent were authorized by Congress for all research contracts of the Department of Health, Education and Welfare, NSF withdrew its

plans for approving full overhead charges. ECRC is lending its support to more favorable action at the next session of Congress.

4. *Renewal of Government Contracts.* Because the Federal Government is so near its debt limit, some new contracts and contract extensions are being withheld by some agencies. This is causing difficulties at some institutions.

c. *Subject Matter Division, C. A. Brown*

1. *Annual Meeting Plans.* A letter following up the fine meeting of chairmen at Cornell is ready for mailing. This is a joint project of both Division Vice Presidents.

2. *Engineering Science Committee.* The names of interested individuals are solicited so that an exploratory meeting can be held during the Annual Meeting at Berkeley.

d. *General Divisions, Glenn Murphy*

1. *Summer Institute for YETs.* Requests have been received for scheduling a meeting at Berkeley. It was agreed no action should be taken until a report of the General Electric summer program is studied.

2. *Report of Nuclear Committee.* The Executive Board *VOTED* to approve the following recommendations for Summer Institutes in 1958 and their administration by the office of the Secretary:

(a) Three of the general or basic type
(b) Three or four of the advanced or specialized type
(c) One for technical institute faculty members

In most cases it is hoped a university with adequate staff and facilities will be cooperating with an AEC installation. Present plans are that universities should be able to assume the full burden of education of this type by 1960.

The Executive Board also *VOTED* to authorize the Secretary to negotiate with AEC to charge one-quarter of his academic salary (plus proportionate retirement, disability, and workmens' compensation payments) to the project and that he also negotiate with the University of Illinois for a release from teaching duties for an equivalent amount of time.

3. *Fall Meeting of Chairmen.* A meeting with the appropriate chairmen is being planned in conjunction with the General Council meeting in October.

e. *Western Sections, C. L. Eckel.* In correspondence with Section officers their functioning as an integral part of the Society is being stressed. Particular items are improved communication, membership, YET paper contest, annual reports, and branch activity.

f. *Eastern Sections, R. W. Van Houten.* Sections are being contacted by letter, and points similar to those mentioned in 3e, above, are being stressed. It was agreed that because of the interests of the CYET and the past lack of attention to Branches, a special meeting of Branch Chairmen should be scheduled for the Berkeley meeting; the Secretary and Vice President for General Divisions and Committees are to cooperate in the planning of this program.

Report of the Editor, *E. C. McClintock, Jr.*

a. *Expansion of Advertising.* About 500 prospects have been identified and divided into six groups. Letters have gone out to some and some advertising has been sold at the new rates. The present rate of income is judged to be about twenty per cent above last year. Data for submission to Standard Rate and Data are completed. The real test of the new rates

will come in about December when most contracts are renewed.

b. *Revision of Publication Schedule.* Since all opinions sought, including the members of the Publication Committee and Lancaster Press, indicated general approval, the plan of having nine regular issues dated October to June, inclusive, with the *Yearbook-Directory* a special February 15 issue, has been adopted. Comments from some advertisers indicated that advertising in the *Yearbook-Directory* was two to three times as valuable as in other issues because of the year-long value of the issue.

c. *Change in Responsibility.* The preparation of data for additions to and changes in membership for the *Yearbook-Directory* has been transferred to the office of the Secretary so that the new Editorial Secretary can devote adequate time to the expansion of advertising and be more helpful in matters pertaining directly to production and editing.

d. *Readership Survey.* Plans are being developed for this new venture.

Engineers' Joint Council

a. *Support of TV Program Series.* The letter ballot "approved in principle" included so many comments that only a "qualified approval in principle" could be given EJC. The comments generally pertained to quality, supervision, and cost. It was agreed that Vice Presidents R. W. Van Houten and R. L. Wooldridge closely cooperate with J. I. Mattill (ASEE's representative on EJC's Public Relations Committee) in protecting ASEE's interests in all programs.

b. *Incorporation.* Some societies are not joining EJC because it has only a C6 tax status as compared to the C3 tax exempt status of most societies. To enable additional societies to join and to better protect present members, incorporation is being sought. The Executive Board *VOTED* to adopt the following policy, "It is desirable for EJC to incorporate so as to maintain its C6 tax classification and absolve member societies from impairing their C3 tax status." It was further agreed a copy of this action be sent to M. M. Boring, ASEE's representative on EJC's Board of Directors, and that he and Vice President R. J. Woodrow keep the Executive Board of ASEE thoroughly informed of all developments.

c. *Invitations to Chicago Conference on Engineering and Scientific Education.* It was agreed that all deans of engineering be invited by EJC, and that the President Lindvall send a letter to the President of EJC expressing ASEE's displeasure at being omitted from the list of sponsors of this national conference, particularly since ASEE has as its unique and primary purpose of existence the study of engineering education.

Other Business

a. *Engineering Science Curricula Committee.* See Item 3c2.

b. *Proposed Award for Engineering Teacher.* All information regarding the proposal and the costs of other awards should be given the Awards Committee.

c. *ASEE–ASTM Conference.* The Secretary reported on an exchange of letters in which ASTM suggested the possibility of a joint conference on the importance of materials in engineering. The Secretary was advised as to a procedure to follow if the suggestion becomes a reality. It also was suggested that technical institute programs of interest to ASTM could be developed.

d. *Recommendation to NSF Board.* The Executive Board *VOTED* to authorize the president to write a letter expressing the Society's support of the

appointment to the NSF Board of T. Keith Glennan and M. P. O'Brien.

e. *Distribution of "Engineering Technician."* The request of the National Science Teachers Association to distribute 11,000 copies of "The Engineering Technician" to high school science teachers was referred to the Technical Institute Division for consideration. It was agreed the Society had no funds to pay for the printing, or purchase, and the $440.00 cost of distribution. Consequently, having the booklet on the reference list may be the best that can be done.

f. *Recruiting Practices and Procedures.* Mention was made of the availability of the U. S. Chamber of Commerce's "Principles and Practices of College Recruiting" and the dissatisfaction of our Ethics Committee with some of the changes made in ASEE's "Recruiting Practices and Procedures" to get the Chamber of Commerce version. It was agreed that in the next newsletter of ECAC there should be an article requesting deans to purchase copies of ASEE's booklet for the use of their placement officers and stating that our Ethics Committee is firm in its contention that ASEE's code" is in keeping with a high professional status of the engineer and should not be "watered down."

Next Meeting

a. *Executive Board.* October 25, New York City, a 6:30 p.m. dinner meeting in the Village Room of Hotel Statler.

b. *General Council.* October 26, New York City, an 8:00 a.m. breakfast meeting in the Dallas Room of Hotel Statler.

Repectfully submitted,

W. Leighton Collins
Secretary

NOTE TO INDUSTRIAL ENGINEERS

Last year when the yearbook data cards were mailed "Industrial Engineering" was accidentally omitted from the list of "occupational fields." Apologies were extended and immediate amends were made by inserting a note on our master copy and in making certain "Industrial Engineering" was listed in the occupational fields on the back of the membership application blank. But everything didn't materialize as planned and, regretfully, this year only "Industrial" (with no connection to members in industry) got on this year's data card. Not many "raised cain" with the Office of the Secretary, but apparently "cain was raised" within the profession. I can only apologize again and say I don't know how "Engineering" got lost. Please rest assured there is no ill will toward the group and, personally, I surely do hope the third time will be the charm!

W. Leighton Collins
Secretary

VIEWS AND NEWS CONTRIBUTED BY

The Young Engineering Teachers

HAROLD A. FOECKE, Chairman
University of Notre Dame

ROBERT D. LARUE, Editor
Colorado State University

THE AUTOMATION OF ENGINEERING EDUCATION

LLOYD B. CRAINE

Associate Electronics Engineer
Engineering Experiment Station, State College of Washington, Pullman

One of the major problems facing engineering education is how to teach an increasing number of students more with a proportionally smaller staff. Traditionally, undergraduate engineering education has been given under a classroom and laboratory system presided over by an instructor. Interspersed among the classical pedagogical procedures have been the instructor's personal efforts at inspiring the student to seek knowledge, to compete with other students, or to avoid being flunked.

This system has produced outstanding graduates and engineers, but the excellent results obtained have been due to the intimate classroom contact between student and teacher. Such rapport will not exist in the future, however, and even now is becoming difficult to achieve as the numbers and size of classes increase for each teacher. We must, therefore, develop a new approach to engineering education which retains the essential contact between a teacher and small groups of students, yet provides facilities for a large enrollment.

Historically, teaching has been one of the oldest professions, and a teacher and a group of disciples the essence of education. The role of the teacher and student has not changed materially through the years, although the division of labor between teacher and student may vary greatly in different systems of education.

The Present

In our present college system, a teacher has a number of tasks to perform during the educational process, many of which do not contribute greatly to the student's education. The average student's contribution has been a passive response; for many students, as well as some teachers, the pursuit of knowledge has been an act of duty rather than a labor of love and devotion.

If we examine the items of the educational process in the same way industry would analyze a process to improve the effectiveness and efficiency of production, "a simple expansion of the numbers of everything," so that teaching could be done in the "good old way," would not be indicated. The heart of the new industrial "Automation" is the separation of the routine from the creative by an internal self-

correcting "feed-back" mechanism. To automate education, it will be necessary to have the teacher retain the creative aspects of teaching while relegating the routines to others. Retention of the close personal association between student and teacher must be the cornerstone of any new approach to engineering education.

Analysis

An examination of the tasks of teacher and student reveals that each one has aspects both of creativeness and routineness. Some are capable of standardization. Engineering education can be automated only by analyzing each of these tasks for its creative and routine content and assigning the tasks to the machine or individual best able to do them efficiently and effectively. Finding other ways to do the routine tasks would free the instructor for the often-neglected creative teaching.

As a prerequisite, however, standardization of certain fundamental undergraduate courses must be accomplished before specific duties can be assigned. Such a program would be facilitated if engineers could agree on the store of fundamental knowledge which is required of an undergraduate student.

The "sameness" of many textbooks shows that some standardization of course content is already taking place. Additions to a student's store of knowledge would be facilitated if textbooks were accompanied by films, demonstrations, and operating models for direct student use.

The present batch-system by classes is inefficient, as the class must be paced by the average student. It is conceivable, however, that with new methods a continuous flow system would result, with the student adapting his progress to his abilities.

The New Method

A first requirement for this system would be a standardization of the basic science and engineering courses, and the preparation of textbooks with accompanying film or TV material. In addition, a selection of practice problems in the use of factual information and routine fact-finding quizzes would be necessary. Laboratory demonstrations and experimental problems would be assigned concurrently with reading material. All course content would be designed for self-study by the student at his own pace, and would of course include the use of a film library.

A data-processing and computing center would be needed to examine the student's routine practice problems and examinations and to deliver the results to the instructor. The center would not analyze just the answers but also the procedure used, even if one of several methods or assumptions was selected by the student. Individual counseling of the particular difficulties of each student would be done by the instructor.

Many of the administrative, record-keeping, and secretarial duties which chain an instructor to hours of unrewarding labor could be handled by secretarial-personnel using the processing and computing center. It should be realized more generally that each instructor is a group supervisor, and as such requires the same type of service personnel as a supervisor in industry: many of industry's administrative tasks, including those involving routine decisions, are done by machine. A staff of technicians to perform maintenance, new construction, and general housekeeping duties should also be established.

Once these tasks have been eliminated, the teacher is free to meet with groups of students at scheduled

intervals for discussions of points in question, injection of new ideas, local examples or applications, the study and analysis of specific cases of immediate interest, and generally to use the factual information gained by the student for self-study toward the creative analysis of complete engineering problems at appropriate levels.

The teacher would then truly become the leader, pointing the way to new discoveries in many fields and demonstrating the necessity for integrated thinking on problems. The keynote is "help yourself to knowledge" with the teacher making the material "live."

Conclusions

In such a system, the responsibility for attendance, interest, alertness, inquisitiveness, and activity would be returned to the student, where it belongs. Such a system might seem to take away most of the present duties of teachers, but this has been shown to be necessary. The reduction of the routine chores and the allocation of creative tasks to the teacher will strengthen the real bulwark of engineering education, the intimate personal contact between student and teacher which will be gravely threatened in years to come.

NSF URGES RESPECT AND UNDERSTANDING OF SCIENTIFIC ENDEAVOR

The National Science Board, 24-member governing body of the National Science Foundation, made the following comments on Soviet space exploration:

The significance of the Soviet accomplishment in exploring outer space has been considered at length by the National Science Board of the National Science Foundation. The Board regarded this as a great scientific and technical achievement and urged that it be recognized as such. The Board further considered it an impressive demonstration of the strong position of Russian science and education.

This event is dramatic evidence of the rapidly accelerating pace in the advance of science and technology. As such it challenges this Nation's determination to strengthen its present scientific position and to make provision for future scientific progress.

The Board urges that both short and long range steps be taken continually to improve our scientific position.

For the short term, the Nation should utilize its scientists and engineers even more effectively, support their efforts better, and select more wisely and with greater discrimination among the many things which our Nation wants and needs.

We must recognize that our Nation's future rests in major degree upon the soundness of our system of education and our people's respect for scientific endeavor, based upon an understanding of its importance in the modern world.

ELECTRICAL ENGINEERING DIVISION

NEWSLETTER

The officers of the Division met immediately following the annual business meeting at Cornell last June to discuss and plan activities for the coming year. A second meeting was held in Chicago in early October. This newsletter represents in part a brief summary of these plans.

1. The publication of a periodic newsletter was considered. It was felt that in view of the difficulty of identifying completely the members of the Division, contact could best be made through the JOURNAL. This procedure was further justified on the basis of relative cost. A second "issue" will appear shortly before the annual meeting.

2. The program for the next annual meeting was planned in outline form. Without breakdown, the program is expected to follow this pattern:

a) Monday evening—Informal get-together of division members
b) Tuesday afternoon—E.E. Session—Methods of Teaching Electrical Engineering to Undergraduates
c) Wednesday noon—Joint luncheon (tentative)
d) Wednesday afternoon—E.E. Session—Physics in the E.E. Curriculum
e) Thursday noon—E.E. Division Business Luncheon
f) Thursday afternoon—Joint session with M.E. Division and others on Heat Transfer and Thermodynamics

3. The matter of an Electrical Engineering Summer School in conjunction with the annual meeting was considered. This will be given further consideration, though no plans are being made to include one this summer.

4. A Nominating Committee has been selected with Dr. S. Reid Warren, Jr. (Asst. Vice-President, University of Pennsylvania, Philadelphia, Pa.) as Chairman.

The officers of the Division felt that this Nominating Committee should have the benefit of suggestions from the membership in submitting its slate of officers. Further, it was proposed that two names be presented on this slate for the office of Secretary. Since it has been general practice, for the sake of continuity, for the officers to progress toward the chairmanship, the Committee may, as in the past, present only one name for each of the other two offices. They will, however, welcome suggestions in this direction. These should reach the Chairman of the Committee by January 15.

5. Division members are requested to contact the officers of the Division concerning suggestions for future programs, activities and operation of the Division, and any other pertinent matters.

OFFICERS OF THE DIVISION

Chairman PROFESSOR J. STUART JOHNSON
Dean of Enginering
Wayne State University
Detroit, Michigan

Vice-Chairman	PROFESSOR AUSTIN V. EASTMAN Professor and Executive Officer Department of Electrical Engg. University of Washington Seattle, Washington
Secretary	PROFESSOR JAMES H. MULLIGAN, JR. Chairman, Department of Electrical Engg. New York University New York 52, New York
Representative on General Council (1957–59)	PROFESSOR SAMUEL SEELY Chairman, Department of Electrical Engg. Case Institute of Technology Cleveland, Ohio

FIELD AND FUNCTION OF ECPD

The following paragraph is quoted from a Preliminary Report of the Planning Committee of ECPD because it so aptly gives a clear picture of ECPD's entire area of activity. One is prone to think only of accreditation, but that is only one aspect of ECPD's efforts.

The geographical area in which ECPD operates is the United States and Canada. All its activities except the accreditation of engineering curricula apply to both countries. ECPD does not accredit Canadian curricula. ECPD has to do with the development of the individual engineer rather than with engineers in groups or with engineering as a whole. Its objective is to aid the individual to become a competent engineer dedicated to the public welfare. To attain its objective, ECPD attempts to reach the potential engineering student in the secondary school as early as the eighth and ninth grades and follow him through his education and experience to the stage where he has attained sufficient stature to become a registered engineer under the various state registration laws and is eligible for election to the full or corporate membership of his engineering society. This activity covers, for the individual, the formative period of his career. The present ECPD program for accomplishing this might be summarized as follows: ECPD guides the high school student into the engineering college; sees to it that the engineering student obtains a sound education in both curricular and extra-curricula areas, and helps the young engineer through the first years of practice. All this is done within a framework of sound professional ethics and attitudes.

Teaching Tip—

ELLIPTIC-TYPE CLOSED CURVES USEFUL IN ENGINEERING MECHANICS

WILL J. WORLEY

Associate Professor of Theoretical and Applied Mechanics, University of Illinois

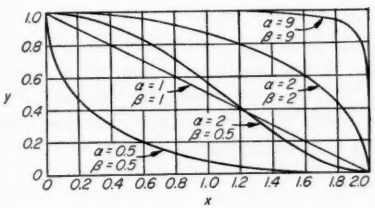

FIG. 1. *Elliptic-type curves.*

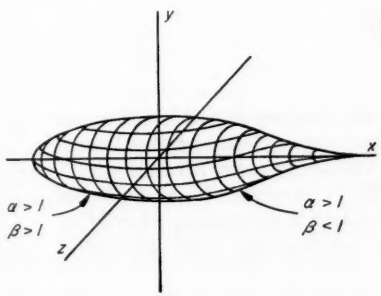

FIG. 2. *Unsymmetrical elliptic-type volume of revolution.*

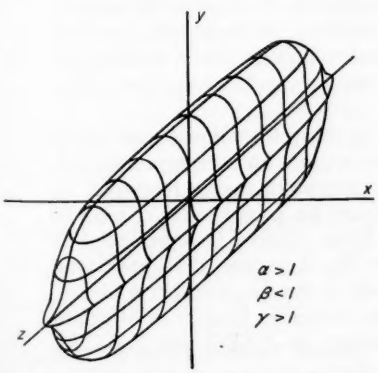

FIG. 3. *General elliptic-type volume.*

Our age of streamlined geometric shapes for guided missiles, airplanes, submarines, automobiles, and even fountain pens can be brought into the engineering mechanics classroom with the aid of elliptic type closed curves. These curves lend themselves to a wide range of interesting as well as aerodynamically and hydrodynamically useful engineering shapes. The student who has exhausted his interest in spheres rolling down an inclined plane may find a new stimulus in rolling ellipsoids of revolution down the plane.

While the following curves were studied for a different engineering purpose, they none the less can be used to enlarge the realm of the student's thinking.

The elliptic-type closed curves represented by the equations

$$\left(\frac{\pm x}{a}\right)^{\alpha} + \left(\frac{\pm y}{b}\right)^{\beta} = 1 \quad (1)$$

and

$$\left(\frac{\pm x}{a}\right)^{\alpha} + \left(\frac{\pm y}{b}\right)^{\beta} + \left(\frac{\pm z}{c}\right)^{\gamma} = 1 \quad (2)$$

include many of the areas and volumes normally encountered in engineering. Among the special cases of Eq. (1) are the diamond, the circle, the ellipse, and the rectangle, which lead to the cone, the sphere, the ellipsoid, and the cylinder when the areas are revolved to generate volumes. The volumes represented by

Eq. (2) include a double rectangular pyramid, an ellipsoid, and a right parallelepiped, among others.

The equations have been developed and a complete discussion is available * for the areas, centroids, and moments of inertia of the area as well as the equations for the volumes of revolution, centroids of volumes of revolution and moment of inertia of volumes of revolution for Eq. (1).

In addition, the equations for the volumes, centroids of volumes and moments of inertia of volumes have been developed for Eq. (2). These equations are expressed in terms of a, b, c, α, β, and γ using Gamma functions to evaluate a particular equation.

They offer the advantage of including the dynamic characteristics of a variety of useful shapes in compact form.

The shapes of some of the possible plane curves defined by Eq. (1) are shown in Figure 1. A volume of revolution appears in Figure 2; $\alpha > 1$, $\beta < 1$ for positive values of x while $\alpha > 1$, $\beta > 1$ for negative values of x. A more general volume described by Eq. (2) is displayed in Figure 3.

* "Elliptic-Type Closed Curves," by Will J. Worley and Fred D. Breuer, *Product Engineering*, Vol. 27, No. 8, Aug. 1957, pp. 141–144.

INTERNATIONAL SURVEY OF ENGINEERING EDUCATION

The EUSEC Third Conference on Engineering Education, attended by delegates from the engineering societies of the United States and Western Europe, met in Paris September 16 through 20. This country was represented by H. H. Armsby, U. S. Office of Education; M. M. Boring, General Electric Company; Harold L. Hazen, Massachusetts Institute of Technology; and Thorndike Saville, New York University.

Devoted to the exchange of ideas and information, the program was developed around questions of method, requirements, and curricula as practiced in the participating countries. Discussion topics included: general education before admission to engineering schools of university level; selection for admission to engineering schools at university level; university-level instruction; practical training before, during, and after engineering studies; and criteria for professional recognition.

A special U. S. A. contribution to the international conference was a bound edition of the American reports on each topic, including all diagrams and charts to be presented, and a foreword by Thorndike Saville. The general report on professional criteria in all member countries, assigned to Dean Saville, is reproduced in full. The volume was prepared by the American delegates, who are appointed by ECPD at the request of the five member societies, and was published for ECPD by The American Society of Mechanical Engineers. Societies participating in USEC are A.S.C.E., A.I.M.E., A.I.E.E., and A.I. Ch. E.

AN ENGINEER'S LIBRARY

Guide to the Profession . . .

This descriptive bibliography was compiled by the Committee on Selection and Guidance of the Engineering College Administrative Council as a "Dean's List" of recommended reading for engineering students. Preliminary arrangements have been made with the Engineering Libraries Committee of ASEE for possibly supplementing the basic list and preparing other special bibliographies of interest to the membership of ASEE.

Cohen, I. Bernard. *Science, Servant of Man;* a layman's primer for the age of science. Little, Brown and Co., 1948.

A well-written account of the beginnings and development of scientific research which have resulted in benefits for modern man. In many cases, the research began merely with a desire "to add to the sum of human knowledge." The point made by the author is that pure scientific investigation does pay off and adds to the comfort and well being of mankind. Also, it is pointed out that new developments are derived from and built upon the contributions of many scientific research workers.

Cressy, Edward. *A Hundred Years of Mechanical Engineering.* Macmillan, 1937.

A review of a century of progress in mechanical engineering divided into three parts; the production and distribution of power; materials and processes; and applications of power.

Cross, Hardy. *Engineers and Ivory Towers;* edited and arranged by Robert C. Goodpasture. 1st ed. McGraw-Hill, 1952.

"In the framework of this philosophical book you will find many sound views expressed which will go far to clarify some of the hazy thinking about what an engineer is and how he is to be educated. . . . Qualifies as recommended reading for high school students contemplating an engineering career, engineering students, educators, practicing engineers, and perhaps some who only think they are engineers." *Engineering and Mining Journal,* vol. 153, p. 165, 1952.

Dampier, W. C. *A History of Science and Its Relations with Philosophy and Religion.* 4th ed. Cambridge University Press, 1948.

A general outline of scientific advance and the evolution of scientific thought. The philosophical reflections on the relation of science to life and religion lead to the conclusion science can never resolve the mysteries of existence.

Dunlap, Orrin Elmer. *Radio's 100 Men of Science;* biographical narratives of pathfinders in electronics and television. Harper, 1944.

A history of radio told through the lives of 100 men who have experimented in radio, electronics, and electricity. The lives are chronologically arranged, beginning with Thales of Miletus, in the sixth century B. C. The non-technical summary of each man's contribution makes the book of value for reference purposes.

Finch, James Kip. *Engineering and Western Civilization.* McGraw-Hill, 1951.

The history of fifty centuries of engineering against the backdrop of evolving Western civilization. Relates engineering advances to social

and economic conditions in an effort to provide a guide for future progress.

Fleming, Arthur Percy Morris, and H. J. Brocklehurst. *A History of Engineering.* London, A. & C. Black, Ltd., 1925.

Examination reveals that in every age, engineering in some form is one of the means by which civilization has been advanced. In this book, an effort is made to put engineering advances in perspective relative to the period of which those advances were a part.

Forbes, Robert James. *Man, the Maker;* a history of technology and engineering. Schuman, 1950.

The preface states that this is the story of man's accomplishments in the field of discovery, inventions, and engineering from prehistoric times to the present day. It is limited to such subjects as power resources, transportation and communication, metallurgy, textiles, glass, chemical technology, and certain aspects of civil engineering.

Gregory, John Walter. *The Story of the Road, from the Beginning to the Present Day.* 2nd ed. London, A. & C. Black, 1938.

Roman roads tying together an empire, Chinese roads with many turns to confuse evil spirits, and modern roads as arteries for modern civilization are all considered in this book. Methods of construction and future development of modern roads are also described.

Grinter, Linton Elias, and others. *Engineering Preview;* an introduction to engineering, including the necessary review of science and mathematics. Macmillan, 1945.

"Designed to open the field of engineering to anyone who has the determination to master the subject . . . can be studied most effectively in the senior year in high school or the freshman year in college. . . . Since each author has written widely in his own field, the book brings the mature experience of seven technical writers together to bear upon the reader's problem of developing a proper background for professional engineering study." *Preface.*

Hawkins, Lawrence A. *Adventure Into The Unknown.* Morrow, 1950.

The story of the first fifty years of the General Electric Research Laboratory. Written for the laymen, the volume includes anecdotes about many of the scientists who were and are associated with the laboratory.

Hodgins, Eric, and Magoun, F. Alexander. *Behemoth;* the story of power. Doubleday, Doran. 1932.

An account of the inventions and discoveries in the field of power development and application that have moved our civilization forward from the earliest days when muscles of the human body were the only source of power.

Holmstrom, John Edwin. *Records and Research in Engineering and Industrial Science;* a guide to the sources, processing, and store-keeping of technical knowledge, with a chapter on translating. 2nd ed. rev. and cnl. Chapman, 1947.

Presents some general ideas on the merits of technical research and something of the agencies engaged therein. More specifically is concerned with the pursuit and application of information in print, and with this in mind, the author outlines some of the procedures in the approach to technical literature, the use of libraries and certain refer-

ence aids, indexing, and principles of translation.

Hoover, Theodore Jesse, and Fish, J. C. L. *The Engineering Profession.* 2nd ed. Stanford University Press, 1950.

A discussion of the nature of engineering as a profession, a description of various aspects of engineering, and an objective consideration of qualifications for the profession. A guidebook to engineering for those contemplating entering the field.

Kimball, Dexter S. *I Remember.* McGraw-Hill, 1953.

The recollections of a well known mechanical engineer and educator whose long life closely parallels the developments in his special field as well as the industrial growth of this country.

Kirby, Richard Shelton, and Laurson, Philip Gustave. *Early Years of Modern Civil Engineering.* Yale. 1932.

The story of civil engineering advances from the eighteenth century to the present day, told primarily through the achievements of pioneers in the field. Includes developments in surveying, canals, highways, railroads, bridges, tunnels and subways, water works and water power, sewers, and river and harbor work.

Ley, Willy. *Engineers' Dreams;* diagrams and maps by Willy Ley; illustrated by Isami Kashiwagi. Viking, 1954.

Kirkus says: "Round-up of plans engineers have made but have never carried out for political or financial reasons, through the last century and a half. To mention a few, there are: sea-drome islands for trans-ocean air refueling stations; a tunnel under the English Channel; irrigation of the Jordan River Valley; harnessing power from the sun; the refilling of Lake Chad in Africa."

McGuire, John Gilbert, and Barlow, Howard W. *An Introduction to the Engineering Profession;* concerning engineering orientation and engineering problems. 2nd ed. Addison-Wesley Press, 1951.

For high school students contemplating a career in engineering. Discusses briefly the profession and major fields of engineering, the supporting studies, how the engineer solves problems, the sliderule, logarithms, and mechanics. Includes a number of illustrative problems.

Mees, Charles Edward Kenneth, with the cooperation of J. R. Baker. *The Path of Science.* Wiley, 1946.

An excellent book touching on the growth of civilization and discussing the development of the scientific method, the growth of physical and chemical knowledge, applied science and industrial research, and the path of science in its relation to human society. Dr. Baker contributes a chapter on "The growth of biological ideas."

Miller, John Anderson. *Master Builders of Sixty Centuries.* Appleton-Century, 1938.

An informal account of some of the world's most impressive engineering feats, beginning with the great pyramid and ending with the Panama Canal. The style of presentation is nontechnical.

Mills, John. *The Engineer in Society.* New York, D. Van Nostrand, 1946.

The author, a veteran engineer, believes that much in the world could be improved with an engineering-scientific approach, therefore he urges more participation in govern-

ment by men in the engineering profession. Considers the kind of men and their aptitudes who engineering profession needs.

Montgomery, Elizabeth Rider. *Story Behind Great Inventions.* Rev. ed. Dodd, 1953.

The first edition appeared in 1944. The 1953 edition brings it up to date. New chapters on the A-bomb and H-bomb have been added. The contents include: Printing for poor people, line o'type; when wireless became radio; movies don't move; cotton cleaner; eye that never sleeps; glass that is not glass; bedrooms on wheels; quantity cars; Fulton's folly; sun on earth; general bibliography.

O'Neill, John Joseph. *You And the Universe;* what science reveals. Ives Washburn, Inc., 1946.

"A panoramic review for the laymen of recent developments in many fields of scientific research. Each chapter is comprised of articles selected from those published during the past ten years in the New York *Herald Tribune,* of which the author is Science Editor." Hawkins, R. R., ed. *Scientific, medical and technical books 1945–1948.* National Research Council, 1950. P. 3.

O'Neill, John Joseph. *Engineering the New Age.* Ives Washburn, 1949.

A challenge to engineers to take the initiative in long range planning—whether it be in urban design or flood control, in order that errors of the past might not be repeated. The author is science editor of the New York *Herald Tribune.*

Pupin, Michael Idvorsky. *From Immigrant to Inventor.* Scribner, 1923.

An autobiography of a Serbian immigrant to this country who became a teacher and a scientist of high achievement. The main object of the narrative "has been to describe the rise of idealism in American science, and particularly in physical sciences and related industries." The work has real literary quality, and is an absorbing account of the Americanization of an immigrant.

Reck, Franklin M. *The Dilworth Story.* McGraw-Hill, 1954.

The biography of the man who is generally credited with putting together the first successful Diesel high-speed passenger locomotive and presiding over the creation of the first Deisel freight locomotive. It tells the whole story of how Richard Dilworth, without any formal schooling, rose to become a top engineer and the developer of the Diesel.

Redman, Lawrence Vincent, and Morey, A. V. H. *The Romance of Research.* Appleton-Century, 1933.

Research is defined by the authors as a "systematized effort to gain new knowledge." The book describes methods of scientific research as they have been refined through the centuries, and seeks to impress on the reader the importance of research as an essential of progress.

Steinman, David B. *Builders of the Bridge;* the story of John Roebling and his son. Rev. ed. Harcourt.

A fascinating and informative biography of the builders of the Niagara, Cincinnati, and Brooklyn bridges. The narrative depicts the dramatic aspects of the engineering profession and provides a wealth of bridge lore.

Straub, Hans. *A History of Civil Engineering;* an outline from ancient to modern times. London, L. Hill, 1952.

Translated from the German, this volume is a well balanced survey of the evolution of civil engineering from its origins—traditional building craft and exact science. The synthesis of these twin origins is the story of modern civil engineering. A number of informative illustrations supplement the well written text.

Usher, Abbott Payson. *A History of Mechanical Inventions.* Rev. ed. Harvard University Press, 1954.

Discusses the significance of technology, and the processes of invention, and traces, from the earliest records, the development of invention in certain fields, including clocks, water-wheels, windmills, machine tools, textiles, printing, and power production.

Williams, Clement Clarence. *Building An Engineering Career.* 2nd ed. McGraw-Hill, 1946.

A survey of the scope of the several divisions of engineering, coupled with chapters on objectives of engineering education and information on how to study engineering. The final section of the book is devoted to achievements in the major engineering fields.

Yost, Edna. *Modern American Engineers.* Lippincott. 1952.

Biographies of twelve engineers that should provide the reader with some concept of the scope of the profession and serve as an introduction to the nature of some of the divisions of engineering.

AEC TO PUBLISH NUCLEAR ENGINEERING DATA

The publishing of a NUCLEAR ENGINEERING SERIES, undertaken to serve industry and education, has recently been announced by the Director of Information Services for the U. S. Atomic Energy Commission. Through this series, the Commission hopes to organize, chiefly for engineers, the vast technical information generated in the extensive nuclear research and development programs of the government.

One of the first volumes to appear in this series is a 233-page, illustrated edition entitled, *Experimental Boiling Water Reactor.* The book deals with the research reactor constructed at Argonne National Laboratory.

Forthcoming volumes include, *Atomic Energy Facts, Neutron and Gamma Irradiation Facilities, and Hot Laboratory Equipment.* The books in this series are paper-bound and can be purchased from the superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.

NEW MEMBERS OF ASEE

As of October 11, 1957

AHUJA, ARJAN D., Lecturer in Electrical Engineering, The City College of New York, New York 33. William T. Hunt, Jr., C. Froehlick.

ANDERWALD, CARL J., Associate in Education Department, University of the State of New York, Albany. H. Walter Shaw, Jeanne Miller.

BOLLE, DONALD M., Instructor in Electrical Engineering, Purdue University, West Lafayette, Ind. Paul F. Chenea, John E. Gibson.

BOWHILL, SIDNEY A., Assistant Professor of Electrical Engineering, Pennsylvania State University, University Park. Francis T. Hall, Jr., A. H. Waynick.

BUZZELL, JAMES C., JR., Instructor in Engineering Graphics, University of Maine, Orono. Claude Z. Westfall, Ernest R. Deidhaas. Divisional Interest: Eng. Dr.; C. E.

CALLAHAN, CHARLES J., Instructor in Mathematics and Science, Lain Technical Institute, Indianapolis, Ind. Thalma J. Lain, R. E. Langston. Divisional Interest: Tech. Inst.; Math.; Physics.

CHANCE, WILLIAM W., Associate Professor of Humanities and Social Studies, The Montana School of Mines, Butte. W. Clifford Laity, Koehler Stout.

CHIPMAN, ROBERT A., Professor of Electronics Electrical Engineering, University of Toledo, Toledo, Ohio. W. Sherman Smith, E. W. Weave, Jr.

CLOUGH, RICHARD H., Associate Professor of Civil Engineering, University of New Mexico, Albuquerque. W. C. Wagner, Richard G. Huzarski.

COOLEY, COLVIN C., Assistant Professor of Engineering Drawing, University of Detroit, Detroit, Mich. H. C. Gudebski, Leon S. Kowalczyk.

DOUGLAS, CLARENCE J., Associate Professor of Civil Engineering, Norwich University, Northfield, Vt. J. D. Strong, L. M. Laushey.

FELLOWS, DOUGLAS M., Administrative Director, Ward School of Electronics, University of Hartford, Hartford, Conn. Leo F. Smith, Earle M. Morecock. Divisional Interest: Admin. Educ.; Electronics; Tech. Inst.

HARCOURT, BERNARD C., Instructor in Engineering, Lowell Technological Institute, Lowell, Mass. Maurice E. Gelinas, James A. Irvine.

HYMAN, HARRIS, Instructor in Engineering Drawing, New York University, University Heights, New York 53. Irwin Wladaver, L. O. Johnson.

HASSELL, HORACE P., JR., Assistant Professor of Industrial Engineering, University of Tennessee, Knoxville. Robert M. LaForge, Howard P. Emerson. Divisional Interest: I. E.

HAWRY, HENRY J., Instructor in Technical Drawing, Illinois Institute of Technology, Chicago. J. T. Dygdon, R. O. Loving. Divisional Interest: Eng. Dr.

HOLUB, ARTHUR J., Instructor in Electrical Engineering, Purdue University, West Lafayette, Ind. Paul F. Chenea, Fritz J. Friedlaender.

HUSSONG, HOWARD L., Instructor in Industrial Technology, Lain Technical Institute, Indianapolis, Ind. Thelma J. Lain, R. E. Langston. Divisional Interest: Tech. Inst.; I. E.

INMAN, ROBERT M., Teaching Assistant in Engineering, University of California, Los Angeles. L. L. Grandi, Ellis F. King. Divisional Interest: Aeron., Aero. E.; M. E.

ISBELL, ROBERT L., Assistant Professor of Mechanical Engineering, Valparaiso University, Valparaiso, Ind. Warren J. Luzadder, Herman C. Hesse.

KING, DAVID L., Instructor of Architecture, Lain Technical Institute, Indianapolis, Ind. Thelma J. Lain, R. E. Langston. Divisional Interest: Tech. Inst.; Arch.

KOEPSELL, PAUL L., Assistant Professor of Civil Engineering, South Dakota State College, College Station. Jack S. Petersen, Emory E. Johnson.

LESCARBEAU, ROLAND F., Director of Training, Ward School of Electronics, Hartford, Conn. Leo F. Smith, Earle

M. Morecock. Divisional Interest: Admin. Educ.; Tech. Inst.

LIGHT, KENNETH F., Instructor in Mechanical Engineering, Michigan College of Mines and Technology, Houghton. Jean A. Anderson, Chester Foster.

MEDFORD, ROBERT C., Instructor in Engineering Drawing, University of Detroit, Detroit, Mich. H. Gudebski, Leon S. Kowalczyk.

MENTZER, JOHN R., Professor of Engineering Science, Pennsylvania State University, University Park. H. I. Tarpley, Francis Hall, Jr.

MILLER, ROBERT F., Instructor in Industrial Engineering, The Ohio State University, Columbus. Thomas H. Rockwell, David F. Baker. Divisional Interest: I. E.; Math.

MURPHY, RICHARD S., Instructor in Civil Engineering, Southern Methodist University, Dallas, Tex. I. W. Santry, Jr., Sophus Thompson. Divisional Interest: C. E.

NIEDNAGEL, ROLAND E., Instructor-Field Registrar, Lain Technical Institute Evansville, Ind. Thelma J. Lain, R. E. Langston. Divisional Interest: Tech. Inst.; I. E.

PARKHURST, IRA A., Instructor in Industrial Technology, Lain Technical Institute, Evansville, Ind. Thelma J. Lain, R. E. Langston. Divisional Interest: Tech. Inst.; Eng. Dr.

PARSONS, JOHN W., Director of Employee Relations, McGill Manufacturing Company, Inc., Valparaiso, Ind. G. W. Bergren, D. S. Clark.

PEARSALL, SAM H., Instructor in Electrical Engineering, Vanderbilt University, Nashville, Tenn. F. J. Lewis, P. E. Dicker.

PLONSEY, ROBERT, Assistant Professor of Electrical Engineering, Case Institute of Technology, Cleveland, Ohio. Samuel Seely, Beaumont Davison. Divisional Interest: E. E.

RANKIN, JOHN R., JR., Assistant Professor of Electrical Engineering, Rutgers University, New Brunswick, N. J. Samuel Sailor, Paul P. Rice.

RITCHEY, JOHN A., Associate Professor of Industrial Engineering, Purdue University, West Lafayette, Ind. J. H. Greene, Halsey F. Owen.

ROBINSON, DONALD W., Dean of Students, Indiana Technical College, Fort Wayne, Ind. Robert C. Ruhl, C. A. Overholt. Divisional Interest: Admin. Educ.; Psych.

RUBLE, GEORGE B., Instructor in Electrical Engineering, Rutgers University, New Brunswick, ,N. J. John P. Newton, Samuel Sailor. Divisional Interest: E. E.

SABTO-AGAMI, JACOB C., Lecturer in Electrical Engineering, City College of New York, New York. Egon Brenner, Vincent Deltoro.

SHANDLEY, PAUL D., Assistant Professor of Physics, Michigan College of Mining and Technology, Houghton. Robert A. Janke, Chester J. Pratt.

SHOCKLEY, CLYDE A., JR., Instructor in Applied Mechanics, University of Wichita, Wichita, Kan. Everett L. Cook, Loring O. Hanson. Divisional Interest: Mech. and Mat.; C. E.

STUBBS, HAROLD L., Professor of Mathematics, Northeastern University, Boston, Mass. Wililam T. Alexander, Joseph Spear.

THIELHELM, HAROLD W., Supervisor, Technical Services in Engineering, Arabian American Oil Company, Dhahran, Saudi Arabia. Harry R. Snyder, Boris W. Boguslavsky.

TRUHN, KENNETH W., Project Engineer, Sr. in Engineering, Scintilla Division, Bendix Aviation Corporation, Unadilla, N. Y. C. C. Tyrrell, L. J. Sitterlee. Divisional Interest: Admin. Ind.; Coord. of Coop. Engineering; G. E.; En. Dr.

WALTER, ELMER A., Instructor in Geology, St. Louis University, St. Louis, Mo. Victor J. Blum, Victor T. Allen. Divisional Interest: Mineral Tech.; Human.-Soc. Stud.

WARD, HARRY C., Instructor in Engineering Graphics, Tufts University, Medford, Mass. Perry H. Hill, Jr., Arthur W. Leighton. Divisional Interest: Eng. Dr.; M. E.

WARNER, CHARLES H., Instructor in Mechanical Engineering, West Virginia University, Morgantown. R. D. Slonneger, H. M. Cather. Divisional Interest: M. E.

WELCH, WALTER R., Associate Editor, Engineering Books, Prentice-Hall, Inc., Englewood Cliffs, N. J. R. Frank Bitner, E. C. Jordan. Divisional Interest: Admin. Ind.

WILSON, BAYNARD, Assistant Professor of Applied Mechanics, University of Kansas, Lawrence. Kenneth C. Deemer, Kenneth H. Lenzen.

WILSON, CLEMENT C., Instructor in Mechanical Engineering, University of Tennessee, Knoxville. J. Mack Tucker, William K. Stair. Divisional Interest: M. E.; Mech. and Mat.

ZIEHN, ROBERT S., Instructor in Chemistry and Physics, Chicago Technical College, 2000 S. Michigan Avenue, Chicago 16, Ill. L. G. Morey, H. B. Knudsen. Divisional Interest: Physics; Chem.

50 new members
150 previously added

200 new members this year

SUMMER INSTITUTES ON NUCLEAR ENERGY

Professor Leighton Collins, ASEE National Secretary, has announced that the jointly sponsored ASEE–AEC Summer Institutes on Nuclear Energy will be continued in 1958.

Present plans include three eight-week institutes of a general or basic character, three or four specialized eight-week institutes in advanced metallurgy, reactor theory and design, chemical processing, and instrumentation, and sessions specifically for technical institute faculty members.

The program will be essentially the same as those of previous summer institutes. However, it is hoped that qualified engineering colleges will participate more actively this year. The joint cooperation of universities and government facilities will be sought.

Participants in the program must be on the faculties of engineering colleges with one or more curricula accredited by ECPD, or be members of the physics, chemical engineering, or mathematics staffs of institutions involved in developing educational programs for engineers. To finance participation in the institutes, it is expected that the employing institutions will contribute one month's salary, which will be matched by AEC grant to the university to provide two months pay for the attending faculty members. The maximum AEC grant any individual applicant will receive is $750. In addition, each participant will be paid first-class round-trip railroad fare.

Applications are available from the Deans of Engineering and must be submitted to the Secretary's office in January.

TEACHING POSITIONS AVAILABLE

ASSISTANT OR ASSOCIATE PROfessor—To teach undergraduate courses in Aeronautical Engineering and graduate courses in propulsion, instrumentation, or structures. Industrial and teaching experience desired. Opportunities available for further graduate study, consulting, and research. Send resume of education and experience to: Chairman, Department of Aeronautical Engineering, Wayne State University, Detroit 2, Michigan.

ELECTRICAL ENGINEERS. ACAdemic position combining teaching and fundamental experimental research. Assistant Professorship for recent Ph.D. or equivalent background, higher rank in accord with qualifications. Write D. C. Drucker, Chariman, Division of Engineering, Brown University, Providence 12, Rhode Island.

ELECTRICAL ENGINEERING OPENings for February and September, 1958. Rapidly expanding department, modern curriculum. Special opportunities to continue development of courses and laboratory facilities in Network Analysis, Electronics and Feedback Control Systems. Rank and salary dependent upon training and experience; appointments possible at rank of professor. Address Carl S. Roys, Head, Department of Electrical Engineering, University of Massachusetts, Amherst, Mass.

INSTRUCTORS OF CIVIL ENGIneering to teach courses in Engineering Drawing, Descriptive Geometry and Surveying. February and September 1958. Opportunity for graduate work and research. Good promotion policy. Excellent opportunity for development. Write F. A. Biberstein, Head, Department of Civil Engineering, The Catholic University of America, Washington 17, D. C.

ASSISTANT AND ASSOCIATE PROfessors of civil Engineering; one to teach undergraduate and graduate structural engineering and one to teach in strength, properties, and testing of materials. M.S. required, P.E. preferred. Rank and salary dependent upon qualifications. Opportunity for research. Good promotion policy. Positions Available February or September, 1958. Write to F. A. Biberstein, Head, Department of Civil Engineering, The Catholic University of America, Washington 17, D. C.

ELECTRICAL ENGINEERING INstructor or assistant Professor. M.S. degree preferred. Salary and rank based on education and experience. Send resume to Dr. John E. Foster, President, New Bedford Institute of Technology, New Bedford, Massachusetts.

ELECTRICAL & MECHANICAL ENgineering. Academic rank and salaries open. Opportunities for consulting work in addition to teaching if desired. Recently formed, growing departments. Write to the respective departments, University of Mississippi, University, Mississippi.

MECHANICAL ENGINEERING. Open September, 1958. To teach machine design and related courses at undergraduate level and assist in development of graduate program in design. M.S. required. Salary open. New facilities with excellent working conditions. Apply to Head of Mechanical Engineering, Colorado State University, Fort Collins.

PHYSICAL METALLURGY, MATERials engineering. Well staffed, well equipped, and nicely situated, growing university. Position in fall, 1958, to accommodate increasing enrollment. Salary based on experience and training. Contact Professor W. H. Weaver, Head, Mechanical Engineering, University of Massachusetts, Amherst, Massachusetts.

ESSEX COLLEGE, ASSUMPTION University of Windsor, Ontario announces faculty openings for:

Civil Engineers
Electrical Engineers
Mechanical Engineers

Graduate degrees or equivalent preferred, teaching experience desirable. Salaries open, depending on qualifications. Medical, Hospital, and Pension plans. An appointment in each of these three fields for fall of 1958, with further additions being made in subsequent years. Write Chairman of Staff Committee.

UNUSUAL OPPORTUNITY FOR A young Ph.D., in Electrical Engineering Department of an Engineering School with dynamic administration. Exceptional opportunity for very rapid advancement. Apply to Chairman Clifford C. Carr, Electrical Engineering, Pratt Institute, Brooklyn 5, New York.

MECHANICAL ENGINEERING FACulty needed for courses in thermodynamics, heat transfer, fluid mechanics, and laboratories. Also electrical engineering faculty needed qualified in power engineering, basically in the field of circuits. Someone in electronics could be used. Persons should have teaching and industrial experience. Salary and rank dependent upon degree and experience. Positions now open. Apply to Dr. Hildred B. Jones, Dean of University, Ohio Northern University, Ada, Ohio.

ELECTRICAL AND MECHANICAL Engineering positions open. Teaching assignments are Electric Power, Electronics, Mechanical Vibrations, Fluid Mechanics, and other Mechanical Engineering subjects. Salary depends upon qualifications. Excellent fringe benefits. M.S. in Electrical or Mechanical Engineering desired. Applicants with B.S. considered. Write to Earle M. Morecock, Chairman, Applied Science Division, Rochester Institute of Technology, Rochester, New York.

POSTDOCTORAL AID IN STATISTICS

The Department of Statistics, University of Chicago, has recently announced a program of postdoctoral awards in statistics, established under grant from the Rockefeller foundation. The awards are available to recipients of the doctoral degree in one of the physical, biological, or social sciences to which statistics can be applied, and range from $3,600 to $5,000 for an eleven-month residency. Applications for the 1958–59 academic year will be accepted until February 15, 1958. Further information can be obtained from the Department of Statistics, Eckhart Hall, University of Chicago, Chicago 37, Illinois.

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